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TEAM TRAINING:
LITERATURE REVIEW AND ANNOTATED BIBLIOGRAPHY

By

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Final Report

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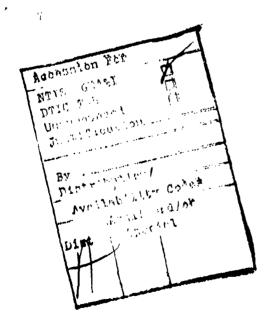
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A review of the literature on team training is presented. The source material was derived from government documents, industry reports, journal articles, and books. The objective of this effort was to conduct a comprehensive review of the team training literature in order to establish a baseline of what is currently known and to identify unresolved technical issues relevant to Air Force team training. In addition, recommendations concerning the most important areas for Air Force team training R&D were to be made. An attempt was made to be as comprehensive as was considered practical. Documents dated prior to 1960 and the preponderance of research on small group behavior within a social psychological context were limited to a few representative review articles. Hundreds of source documents were investigated to obtain just over 100 relevant reports that focus on definitional

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issues; individual, task, and team characteristics of team training; the role of feedback; performance objectives; measurement and evaluation; and the potential of instructional system development for effective team training. The appendix contains an annotated bibliography. The review is intended to serve as a basis and a resource for the improvement of the state-of-the-art in team training.

Objective

The objectives of this effort were a comprehensive review of the team training literature and an identification of the most important areas for Air Force team training research and development (R&D).

Background/Rationale

To meet peacetime readiness and wartime employment objectives, Air Force personnel must perform effectively in teams; therefore, some type of team training is necessary. The efficiency and effectiveness of this team training is a matter of high priority.

Unfortunately, little R&D has been conducted on team training. As a consequence, the technology of team training is poorly developed. Proven techniques and methods are not available to support the specification of team training requirements and the development of team training programs. This study was made to clarify the pertinent technology and to identify needed R&D. The results of this study will be used by the Laboratory in planning R&D on team training. Some findings will be of use in planning team training programs.

Approach

Pertinent materials were sought from all sources. Documents prior to 1960 and research on small group behavior within a social psychological context were limited to a few representative review articles. Hundreds of source documents were reduced to approximately 100 relevant reports. The appendix contains an annotated bibliography.

Specifics

Findings are presented on the following issues: definitions, individual characteristics, task characteristics, team characteristics, knowledge of results (feedback), performance objectives/measurement/evaluation, and instructional system development.

The characteristics used to define "a team" strongly influence the variables which are investigated. One popular view of a team includes hardware and software capabilities, and the limitations and interactions of these with people, as research parameters. Another view of the team involves a "synthetic organism" conceptualization which emphasizes adaptation, group feedback, and an emphasis on the cognitive aspects of learning. Yet another approach emphasizes the stimulus-response aspects of learning and concentrates on the individual and his contribution to the team product.

Individual characteristics, learner strategies, and decision-making abilities affect the functioning of a team. Some essential capabilities can be developed through training; others can not. At times it is necessary to select team members with the necessary characteristics, rather than depend on training to develop the capability.

The research reviewed supports an "established-emergent" task distinction as a critical consideration in the training of teams. An established situation is one in which conditions are specifiable and predictions can be made about the probable consequences of alternative actions. An emergent situation lacks specific environmental conditions, does not correspond to relied-upon predictions, and resists analytic solutions. Whether conditions can be anticipated and prepared for has an obvious impact on what should, or even can, be trained. Other task considerations include task load, which appears to be a measure of task difficulty, and the adequacy and appropriateness of training objectives.

Cooperation, coordination, and communication appear to be significant parameters in the training of teams. The considerable evidence that has been collected suggests that these may be the qualities that cause team output, especially in emergent situations, to appear to exceed the sum of individual outputs. Team organization, structure, composition, and size also appear to contribute to team effectiveness in complex ways.

It seems appropriate to vary the type of feedback provided (individual or group) with the model of the team adopted. If the team is viewed as an organismic entity, then group feedback is appropriate. If the individual contributions of team members are considered more important, then individual feedback is more appropriate. If the opinion is that a team is some combination of both, then a combination of group and individual feedback commensurate with their relative contributions to team output seems appropriate.

Adequate measurement of team performance measurement is essential both for R&D and operational team training. This area is not well defined and to some degree reflects the ambiguities associated with the definition of the team itself, team behaviors, and team functions. This is an area in which there is a clear need for systematic investigation.

An essential step in improvement of current team training technology is development of a systematic approach to team training programs. Current Instructional System Development (ISD) technology does not provide an adequate means for identification and consideration of team training requirements. It focuses on identification of individual training requirements. As an initial and manageable first step in an effort to develop a methodology for team training, high priority should be given to development of adequate task or function analytic techniques for use in the identification and description of team training requirements.

Conclusions and Recommandations

Interest in team training rests on the assumption that team output is something more than the sum of individual outputs and that some distinctive elements determine team effectiveness and efficiency. Unfortunately, the identification, quantification, application, measurement, and evaluation of these elements have proven quite elusive. Despite an impressive amount of research conducted in the team training area to date, major issues remain to be investigated in each of the areas included in this review, particularly as they relate to the military training environment.

Team training is essential for producing and maintaining critical proficiency in many types of operational units. A systematic program of R&D should be undertaken to ensure effective and efficient performance of military teams. A reasonable first step would be to determine how team training currently is conducted. A thorough assessment of the current status of team training should identify issues that can be addressed with technology which is currently available or easily modified. Such an assessment also would identify problem issues requiring further research.

The lack of adequate assessment/measurement techniques for team behaviors is another area of high potential payoff. A third area of high payoff is modification of ISD techniques for the identification of interaction, communication, coordination, decision making, composition, structure, and other (perhaps as yet unidentified) team performance variables. This review should be useful in structuring an R&D program on team training.

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PREFACE

A review of the literature on team training was conducted by the Logistics and Technical Training Division of the Air Force Human Resources Laboratory, Wright-Patterson Air Force Base, Ohio, between June and September 1979. The effort supports Project 1710, Training for Advanced Air Force Systems, Mr. Bertram Cream, Project Scientist; Task 1710-03, Training Implications of New Military Technology, Mr. Bertram Cream, Task Scientist; Work Unit 1710-03-47, Team Training (T^2) for Command, Control, and Communication (C^3) System Operators, Mr. Roland Denson, Work Unit Monitor. The review was accomplished in-house to serve as a data base from which contractor as well as in-house investigations of C^3T^2 would emerge.

Acknowledgment and appreciation are extended to Mr. Bertram Cream, Dr. F. Thomas Eggemeier, and Dr. Gordon Eckstrand for their careful review and comments.

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I. INTRODUCTION

> While everyone professes intuitively to be able to
> recognize a good team, (the "I'll know it when I see it"
> phenomenon) no one seems to be able to articulate its
> dimensions with sufficient clarity to permit the
> development of training procedures for producing it.
> —Hall & Rizzo, 1975

The ability of the Air Force to operate and maintain its weapon and support systems to meet peacetime readiness and wartime deployment objectives depends, to a significant degree, on the ability of Air Force personnel to perform effectively in a team environment. In recognition of this fact, some type of team training is usually the final preparation for operational readiness. The efficiency and effectiveness with which this team training is conducted is obviously a matter of high priority. Unfortunately, while the Air Force has invested considerable resources in Research and Development (R&D) on individual training, team training has been almost completely neglected as a subject for R&D. As a consequence, the technology of team training is poorly developed, and proven techniques and methods are not available to support the specification of team training requirements and the development of team training programs.

Over 15 years ago, Eckstrand (1964) noted that ". . . .a psychology of training is developing which is separate and distinct from a psychology of learning; separate and distinct in terms of the goals, hypotheses, methods of investigation, and criteria by which its development is measured." This psychology of training and many of the considerations that impact the team training domain are addressed in this report.

Several major factors that potentially influence the conduct and effectiveness of team training have been identified in the process of this review. These factors include the characteristics of the individual team members and of the task to be performed, as well as the characteristics of the team itself, the use of knowledge of results, and the development and evaluation of team performance objectives. Each of these major subfactors constitutes a portion of this review.

Occasionally, the issues raised may be examined as discrete entities, such as team versus multi-individual assessments which lead either to measures of team performance or measures comprised of the sum of individual performances. Another type of discrete choice may be made between the parameters that a researcher wishes to control (e.g., varying input fidelity or output fidelity). These discrete choices are arbitrary designations, but the majority of the issues affecting teams and their training preparation can be most appropriately placed on a continuum at various points between the extremes. An issue might involve the amount of feedback required for effective team training rather than whether or not to provide knowledge of results. It may not be possible to describe a situation as "established" or "emergent" (Boguslaw & Porter, 1962), but as some combination of both. It is sometimes apparent that a task may be many different things at once. For example, a task may be both a response to a stimulus and a stimulus to additional responses.

These and other considerations are often found to be situation specific. That is, they change in importance or in applicability, depending on what is to be accomplished. The constant in any study should be the unit of work being investigated. In order to contrast and compare studies and findings, the

performance units being discussed should also be equivalent. The issue is one of some magnitude as quite often equivalency of terminology was not the case in the literature reviewed. The team has many aliases (and as many definitions): i.e., group, small group, crew, unit, multi-individuals, or squad to name a few. A review of many of these aliases is contained in the next section.

The source material for this review of the team training literature was derived from government documents, industry reports, and journal publications. The resources searched for relevant material included (a) Psychological Abstracts, (b) the National Technical Information Service (NTIS), (c) the Educational Research Information Center (ERIC), (d) the Air Force Wright Aeronautical Laboratories (AFWAL) Library, (e) the Defense Technical Information Center (DTIC), (f) the Computerized Automated Data on Instructional Technology (ADIT) file, (g) the collection of documents maintained at the Air Force Human Resources Laboratory (AFHRL) at Wright-Patterson Air Force Base, and (h) the libraries of Wright State University and of the University of Dayton.

The literature review was as comprehensive as practical within the constraints of time and available resources. Documents prior to 1960 and the preponderance of research on small group behavior within a social psychological context were limited to a few representative review articles. The goal was to identify current issues in team training as they most appropriately apply to a military context. No attempt was made to provide definitive answers to issues associated with effective training of teams. The review was not intended to identify specific solutions to team training problems, but rather focused on potentially significant factors in a very complex behavioral process — team learning and team performance. The review is intended to serve as a focal point, a place of departure, and a resource for improving the state-of-the-art in team training.

II. DEFINITIONS

Team

In 1955, Glaser and Glanzer proposed that the primary characteristic which distinguishes a "team" from "a collection of individuals" is the team-communication structure. Communication was operationally defined to include "all interactions between team members and between the team and the environment that are necessary for accomplishing a task." It may be noted that within this definition the communication outputs of one individual may serve as communication inputs for others. Although no formal team communication pattern was assumed, the communication flow between team members was described in terms of input, process, and output with ordering according to the sequence in which they occurred. Team behavior was then analyzed in terms of the dimensions and processes of the communication flow.

Boguslaw and Porter (1962) defined a team in terms which applied to work groups of varying compositions, sizes, and goals. Included in their analysis of team behavior were machines, computer software, and "programs of interaction" which contribute to the achievement of some system goal. The relationships between men, machines, and work procedures were assumed to have meaning to the team only insofar as they facilitate or hinder the accomplishment of the system goal. Boguslaw and Porter's definition of the term "team" followed from their assumption that it should represent more than just the relationship among people. They described "a relationship in which people generate and use work procedures to make possible their interactions with machines, machine procedures, and other people in the pursuit of system objectives." Their definition was an early attempt to distinguish the term "team" from such often interchangeable terms as group, small group, organization, social system, and society.

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Horrocks, Heermann, and Krug (1961) developed their concept of a Navy team from field observations at Navy team training installations. The Navy team was seen as a "task-oriented organization of individuals interacting to achieve a specified goal." "Task-orientation" implied a specifically defined job task and "organization" implied an inter-dependent parts structure in which each member had a specific function. The Horrocks, Krug, and Heermann (1960) description of a "structured and task-oriented group" further implied that the individual members have differentiated roles which are usually designed and imposed from outside the group. This structure enhances task accomplishment, but further, it may pre-determine the direction that task acomplishment takes. "Task orientation," as used, also implied that the group exists for a specific purpose which provides justification for the formation of the group.

Briggs and Naylor (1964) carried the Horrocks, Krug, and Heermann (1960) definition of a team one step further in specificity when they defined it as "a group of two or more operators working in a structured and task- or goal-oriented environment." The structure was considered formal in the sense that the organization of the structure defined the functions to be carried out, the sequence of the functions, and the nature of interactions among individuals. Naylor and Briggs (1965) considered this "structure" and "task orientation" to be the factors which differentiate a team from a small group.

Kennedy (1962) perceived "task-oriented groups" (i.e., teams) as "synthetic organisms" in which individuals become members of a greater entity. The "synthetic organism" was described as showing a cohesiveness not unlike the cells and organs of a biological organism. This "biological organism" hypothesis of the team focused easily upon growth, development, and life-cycle changes as salient features. There were three concepts assumed to form the basis of this development process: (a) the development by an individual team member of the ability to relate his/her task to the functioning of the entire team, (b) the development of some awareness of the range and limits of possible input conditions, their frequencies, and relative importances and a capacity to anticipate, and (c) the development of an ability to adjust quickly and appropriately to unexpected situations. Collins (1977) summed it up:

> Rather than limiting the observations to input-output
> conditions and inferring what transpires between the two,
> this position focused on the process of adaptation by the
> team to emergent characteristics of the environment,
> emphasizing cognitive aspects of learning.

Alexander and Cooperband (1965) gave no implication of team performance as a psychological (or biological) product of some team entity. They referred to team outputs as the integration of individual member reactions to common situations. Team performance was considered an aggregate of the behaviors of the team members, influenced by a set of conceptualizations each member has about the environment. They did allow, however, that "the capacity of the team for performing tasks depends not only upon the individual capabilities of its members but also upon the way these capabilities are coordinated." That is, the structure and coordination rules are not necessarily individual member characteristics, but are properties of the team entity.

Glanzer (1961) found it more difficult to deal with teams as simple units with measurable characteristics. Glanzer studied several types of Navy teams in the field and recorded their activities in detail. Problems of unclear team boundaries, unstable team structure and composition, lack of centralization, interaction and coordination overloading, and self-generated team inputs led Glanzer to focus on individuals and their responses within the team.

Similar to the Boguslaw and Porter definition of teams, Klaus and Glaser (1968) of the American Institutes for Research Team Training Laboratory felt that a shortcoming of most research studies on working teams was a failure to recognize that members of such teams are highly specialized and have roles

that are either assigned or determined primarily by the hardware with which they work. Studies designed to determine the effects of varying structural configurations and team organization have had to contend with communication networks and other indices of group structure which often could not be varied beyond very narrow limits while still permitting the group to function even at minimal levels.

Klaus and Glaser, in contrasting the team and the small group, recognized that both may profit by research, but that the kind of research most beneficial to each may differ. Although both terms referred to "collections of individuals acting in consort. . ." a team was considered to be "well organized, highly structured, and to follow relatively formal operating procedures." Teams, as opposed to small groups, were defined as more fixed in terms of structure, organization, and communication lines; having better defined individual assignments which allows better anticipation by other team members; more dependent upon cooperative and coordinated inputs from others; more often performing perceptual-motor tasks; and following established job performance guidance.

Small groups were contrasted as rarely so formal and without well-defined, specialized tasks, and were described as less structured, less organized, and loosely defined in terms of communication networks; having assumed individual contributions; more often requiring complex decision-making skills; and operating with a minimum of specific established guidance.

Hall and Rizzo (1975), in a study designed to gather resource information for planning purposes within Navy tactical team training, discussed the definitional problems of "teams" versus "small groups" cited by Klaus and Glaser and reached a consensus. A compilation of much of the relevant literature was presented and distinctions between teams and small groups were listed. Hall and Rizzo concluded that there are inherent differences in structure and function which distinguish between the two: "Studies of small groups typically involve the modification of organizational variables such as group structure while team research normally emphasizes the manipulation of variables related to tasks and assumes a predetermined and rigid structure and communication network." Even though Hall and Rizzo supported a clear distinction between small groups and teams which clearly suggested different training approaches, they objected to "pat definitions" on the grounds that the complex and variable nature of Navy teams left many questions unanswered. Of concern were the membership and numerical boundaries of a team and whether intermember interaction or communication should constitute a defining factor. It was decided that the minimum characteristics for Navy tactical teams would include a goal or mission orientation, a formal structure, assigned roles, and a requirement for interaction between members. The number of team members was not considered a relevant consideration.

Meister (1976) considered the team the essential element in any multi-member system. While allowing that, in many ways, a team functions like an individual by responding to a mission requirement, performing tasks, receiving feedback, holding goals in common, and adjusting behavior. Meister and many others (Briggs & Naylor, 1964; Daniels, Alden, Kanarick, Gray, & Feuge, 1972; Defense Science Board, 1976; Haines, 1965; Nieva, Fleishman, & Rieck, 1978) considered the distinctive team element to be the interaction among team members. Attempts to focus on team interaction have traditionally investigated some form of communication. In contrasting teams with groups, Meister allowed that the difference is a matter of degree, but described the critical difference as that teams are externally directed by mission requirements, procedures, and instructions while groups are more internally or self directed.

Meister cautioned that no conceptual definition of a team is applicable in all circumstances. The composition, distribution of personnel, behaviors observed, and interaction patterns all may vary during different tasks or at different times. Concern was also expressed as to what defines team membership. Candidates might include presence during a team activity or the degree of interaction/communication. A distinction was also drawn between an individual's "immediate" team (usually relatively small and interactive) and his/her "extended" team in which the immediate team is embedded. Team activity presented an additional defining difficulty. Should the unit of measurable activity include everything that a team does during the team activity (including incidental as well as critical functions and their

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interactions), or should it include discrete functions only (perhaps overlooking interactive aspects)? The point that Meister was driving home is that "the team as an observable entity may be very different from the team as a construct."

Team Training

The definition of team training is confounded in much the same way as the definition of a team. The underlying assumption of team training is that there are distinctive elements which determine the efficiency of a team. It is these elements that must be trained. There has been little success to date in specifying what must be acquired which is more than a combination of individual member skills. It is this difficulty that accounts for the fact that teamwork is not often taught in terms of skills and behaviors, but by providing a context within which the individual practices with others (Meister, 1976).

Klaus and Glaser (1968) in developing a conceptual framework within which to study team training viewed the team as a "single response unit, or module, having performance characteristics which can be subjected to a variety of influences or contingencies similar to those which have been previously demonstrated to be effective in modifying the responses of individuals." Their approach assumed the posture and principles of operant conditioning theory. The team product, rather than individual contributions, was the focus of their training research.

Boguslaw and Porter (1962), in their analysis of team functions and training, offered a very broad definition of team training as "any experience in which a team engages which results in a change of team function, team organization, or team performance." The evidence that team training has occurred is in the changes or adaptations made as a result of experience. The experience may be planned or it may emerge. The experience that does occur is evident in changes in work procedures, machine procedures, equipment, and proficiency.

Wagner, Hibbbits, Rosenblatt, and Schulz (1977), in a review of team training and evaluation strategies, chose to accept the Glaser, Klaus, and Egerman (1962) distinction between small groups and teams as opposed to adding yet another definition to the literature. They did, however, address the question of team versus multi-individual training. Derived primarily from the Glaser, Klaus, and Egerman discussions, "team training" was defined by Wagner et al., as the training of two or more closely associated individuals. The team is structured and goal-oriented with well-defined member responsibilities. The functioning of the team depends upon coordination inputs from all members and coordination and other related interactive activities are the appropriate focus of team training.

"Multi-individual training" was distinguished as focused on individual skills, activities, and products produced by individuals who are associated in a group context.

Alexander and Cooperband (1965) referred to team learning, perception, and behavior in general as evidence that the members of the team have "reacted to a common situation and have produced a product which integrates all the individual contributions." Team performance was considered an aggregate of the behavioral interactions of the individuals. There was no implication of a psychological product of the team considered as an "organism." Even so, it is interesting and useful to include the view of the team as a unit of investigation and to study what factors influence its functioning.

Summary

Those defining characteristics of a team that are adopted strongly influence the research models used. The model, in turn, influences the variables which are investigated. The view of the team that is held, therefore, dictates the contents of the data base by directing the research that is accomplished.

Boguslaw and Porter's (1962) definition led to the inclusion of hardware and software capabilities and limitations and the interactions of these with people as research parameters. Kennedy's (1962) view of the team as a developing "synthetic organism" led to investigations of adaptation and group feedback and an emphasis on the cognitive aspects of learning. Klaus and Glaser's (1968) stimulus-response view of the team led to research emphasis on the individual's proficiency and contribution to the team product.

It is reasonable that the three examples cited are each appropriate in a different context. Where little or no interaction among team members is necessary for the successful completion of a task the stimulus-response model emphasizing the individual may be most useful for describing the team learning and performance process. Where there is considerable interaction and intermember dependency, individual characteristics may be lost in higher order interactions and the only meaningful view of the team may be as a developing entity. In those situations where hardware and software can be sufficiently varied to be considered factors, their inclusion in the model seems appropriate. It is unlikely, however, that any team situation will be comprised of entirely interactive or entirely non-interactive processes, nor that hardware and software is either fixed or can be varied beyond reasonable limits.

Perhaps the most operationally relevant definitional approach is a hybrid one that evolves with the relative position of the task on an interactive-noninteractive contimuum. Consideration should be given to factors such as the hardware and software limitations, the composition of the team, its size, and the criticality of its mission.

The defining characteristics of a team should be derived from the team of primary interest to the researcher. An assessment should be made as to where that team is positioned on the relevant continua (if, in fact, a continuum is appropriate) and the definition allowed to emerge from the team characteristics. If, for example, the team of interest is within the command, control, and communication (C^3) domain, the defining characteristics (and thereby the model) will be influenced by the interactive nature of the mission, the hardware/software limitations of the equipment, and the extreme criticality of the task. This critically will bear on individual proficiency requirements while the uncertainty of what will be required may demand the development of something more than the sum of individual contributions.

It is important that the definition and the model reflect accurately the parameters with a high potential payoff, as these factors will certainly impact the conduct of the research.

III. INDIVIDUAL CHARACTERISTICS

Individual Entry Characteristics and Learner Strategies

Thurmond and Kribs (1978), in their evaluation and demonstration of the feasibility of developing computerized collective training for teams ($COLT^2$), delineated several characteristics of the individual which influence team learning and should be considered in the design of team training:

1. "Knowledge of own roles" was described as an understanding of the authority, responsibility, and duties of other team members and the ability to assess the capacity of oneself and other team members to fulfill the prescribed roles.

2. "Team attitudes" such as confidence, aggressiveness, and pride were emphasized as related to achievement of a team goal.

3. "Team communication" was described as an important part of a coordination task and that individuals trained in such skills develop more effective performance in a team.

4. "Intellectual aptitude and availability of strategy skills" were viewed as related to the handling of conceptual complexity (the capacity to integrate and interrelate dimensional units of information). These seemed to be important factors in determining the type of learner strategies upon which an individual can call.

5. "Personality variables" such as dogmatism, tolerance of ambiguity, and locus of control were believed to influence team performance. These variables were considered potentially useful for communication training involving risk willingness or reluctance.

6. "Cognitive style" was included as a characteristic which creates boundaries on the types of learner strategies available to individuals. Cognitive styles were considered preferences in perceptual organizing and conceptual categorizing of the environment and important to adaptive instructional methods which match media or level of difficulty to the learner.

7. "Memory strategies" were considered important in determining which information is entered into and retrieved from short- and long-term storage.

8. "Problem solving strategies" were divided into "closed-system" problem strategies and "open-system" problem strategies. Closed-system problems are characterized by the existence of an identifiable solution, whereas open-system problems require the problem-solver to go beyond the units immediately given in order to discover a solution.

The above examples of individual entry characteristics and learner strategies may impact the design and manipulation of learning events and instructional materials. The research devoted to these variables has indicated that significant differences in performance and achievement have been attributed to the individual's composite of values related to these variables (Thurmond & Kribs, 1978). It does seem, however, that the characteristics and strategies reviewed by Thurmond and Kribs contribute to team effectiveness only to the extent that they impact individual capabilities and proficiencies. In this respect, they exert a greater influence in non-interactive contexts. This is not to suggest that these factors should be overlooked in an interactive team, but that they fall closer to the non-interactive end of a continuum.

Complementary Task Model

Laughlin and Johnson (1966) conducted a test of a "complementary-type task model" which assumed that each team member possesses some resources that are not shared by the other team members. The combination of these unique resources within a team is one factor that gives team performance superiority over the performance of the same individuals working independently. The effects of group versus individual performance on a concept formation task were investigated as a function of individual ability '. Subjects were categorized into high (H), and medium (M), or low (L) ability levels on the basis c es on a concept mastery pre-test. The test was then retaken by the subjects alone and in ability combinations taken two at a time (HH, HM, HL, MM, ML, LL). Results indicated that subjects working with partners of lesser ability did not improve relative to subjects of the same ability level working alone. Subjects working with partners of greater or comparable ability did improve relative to subjects of the same ability level working alone. In the former case, little new information was contributed by the team member of lesser ability, while in the latter case, each partner brings new information to the team arrangement. Results were interpreted in support of the complementary model.

Trainability of Abilities

Hogan (1978) has presented indirect evidence from selected areas of the nonspecific transfer literature to support the notion that abilities such as those considered by Thurmond and Kribs can be

trained. Areas investigated in the Hogan study included early experimental memory training research, verbal and motor studies of warm-up and learning to learn, effects of practice variability and learning without a prototype, and applied and educational training.

Hogan identified three important considerations in analyzing nonspecific transfer: (a) task characteristics tend to be more predictive of transfer than the training materials used, (b) it appeared that training variability within a class of response types facilitates positive transfer, and (c) it was suggested that transfer may be partially mediated by the adoption of a strategy which requires the abstraction of important training features which would be required in the transfer situation.

If training directed at improving abilities is found to result in transfer to several tasks, and to more complex tasks, requiring those abilities, then ability training may provide a more efficient approach to training individuals than training for each specific task (Hogan, 1978).

Decision Making

A major activity of military teams is decision making. Hall and Rizzo (1975) identified four characteristics of tactical decision making: (a) situation diagnosis, (b) hostile environment, (c) selection of optimum alternatives, and (d) some degree of uncertainty. The decisions made within the tactical team context vary from those involving established techniques for decision selection to those involving alternative selection with uncertain outcomes. The amount of uncertainty and ambiguity involved in tactical decision making requires the individual making decisions to draw upon experience with similar situations and to estimate the chance of success in terms of subjective probabilities. Means for preparing decision makers have included generalized training in the behavior of decision making, situation-specific course training, and modeling through the use of training devices.

Swezey (1979) recently applied a "multi-attribute utilities model" to decision making options in a military training analysis situation. The model is a Bayesian-oriented decision-making paradigm which is adaptable to training evaluation research efforts. The technique is a descriptive one which gathers, reports, and updates information as it becomes available. As additional information is received, it is processed in the same manner as the existing pool of information and existing decisions may be revised in light of the new data. The outcomes may be assessed using a variety of techniques including experimentation, judgment, and naturalistic observation. Weights are then derived to reflect the importance of each dimension of value, relative to all others.

A 10-step, proceduralized methodology for applying the multi-attribute utilities technique was described by Edwards et al. (1975) and reported in abbreviated form by Swezey. A listing of the steps follows: (1) Identify the individual or organization, (2) Identify the relevant issues, (3) Identify the important entities for evaluation, (4) Identify the dimensions of value, (5) Prioritize the dimensions, (6) Rate and weight the dimensions, (7) Sum the weights, divide each by the total, and multiply by 100, (8) Locate each entity of importance on a linear 0-100 scale, (9) Calculate utilities with a given formula, and (10) Make decisions based on this maximization of utilities.

The application of the multi-attribute utilities method reported by Swezey was designed to determine what variables to consider for inclusion in the design of improved gunnery ranges for a military antiarmor training system. Nineteen variables were identified as relevant for possible manipulation and were incorporated as entities of interest in the multi-attribute utilities model. Two dimensions of value were identified. Top ranked entities were identified by application of the model and were, therefore, considered to be most critical in the design of gunnery training situations. Four additional variables were identified as significant and the six were incorporated into the training situation. The results obtained

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were compared to a simple judgment analysis model using the same input data, and a Spearman's Rho of 0.77 was found. The two methods agreed on five of the six top ranked attributes.

Three major aspects of the multi-attribute utilities procedure were presented by the author:

1. Its capacity to aggregate judgments over multiple dimensions of value in a probabilistically weighted fashion.

2. Its iterative capability. Should additional data be obtained, the present data may be used as the relevant prior probabilities, and the new data used to modify them according to the specified procedures.

3. Its use of prior opinion by expert judges was considered an appropriate datum to consider as that prior opinion was often based upon empirical data.

Individual-Team Comparisons

Meister (1976) reported a series of experiments which contrasted individual with team training. The task involved a classic "Twenty Questions" game in which subjects were required to identify an object by asking questions. Individual performance were compared with those of two- and four-member teams. Team learning exhibited the same performance curve as did individual learning. Meister pointed out, however, that series operations were exclusively tested and that these are not representative of most team situations. The only basic difference found between individual and team operations was a shift in feedback contingencies. There was no more (or different) interaction among team members. The author concluded, then, that the operator tasks did not change when placed in a team context and, as a consequence, similar performance curves might have been expected.

Beasley (1958) compared the performances of individuals with three-member groups (given no particular training) in a maze learning situation. The experimental task was to learn the correct path through a bolt-head maze which involved 44 choice points. Those working in groups were instructed that the product of their collaboration would be scored. Group performance was significantly superior to individual performance in terms of number of trials to criterion (one errorless trial) and number of stereotyped errors, but groups required an appreciably longer amount of time to learn the maze to criterion. Discussion time within groups appeared to account for the additional time required to learn the task. Individuals hesitated less between moves, but did not have the benefit of discussing conflicting potential moves which forced consideration of alternatives. Individual sets to move in the wrong direction were reduced by such considerations.

Meister (1976) also found evidence that individual training on simple or moderately complex tasks was superior to team training, and further, that "team training appears to be relatively ineffective in producing performance beyond that resulting from individual operator training." Research by Horrocks et al. (1960, 1961) and Briggs and Johnson (1967) was cited. Decoding tasks, memorization exercises, and intercept tasks were reported with no significant differences found between individual and team performance.

Hall and Rizzo (1975), in their assessment of U.S. Navy tactical team training, concluded that,

> ...too much emphasis has been placed by the training establishment on attempting to produce teams rather than attempting to produce highly qualified individual performers. There is much research to suggest that individual proficiency is the key to effective team performance and that the coordination required within a team naturally emerges as a result of high levels of individual proficiency. Thus, greater emphasis should be placed on individual training, both initial and refresher, and some testing routines should be developed to insure individual competency prior to participation in team

training exercises. The conclusion is not that team training
should be discontinued, but rather that more emphasis
should be shifted to individual training.

Wagner et al. (1977) did not agree with the Hall and Rizzo (1975) conclusion cited earlier that more emphasis should be placed upon individual rather than team training. Although certain studies suggested that team training was ineffective when the tasks required individual skills, investigations in more emergent contexts demonstrated the utility of team training when interactive skills were important in accomplishing the task (Wagner et al. 1977).

Summary

It seems apparent that those individual characteristics that have been demonstrated to impact team proficiency and can be trained should be trained. Those individual characteristics which are important to team output and cannot be trained should, if practical, be criteria for selection in assigning personnel to a particular team. Consideration should also be given to ensuring that critical individual qualities are available when needed. The Laughlin and Johnson (1966) method of combining unique team member resources deserves consideration as a way of doing so, especially in the area of decision making. The point should reiterated that most team performance investigations require the consideration of something more than the additive combination of individual contributions.

IV. TASK CHARACTERISTICS

One of the major results of the past (few) decades of
military training research has been the recognition of the
importance of task characteristics for the effectiveness of
different training variables.

-Eckstrand, 1964

Established vs. Emergent Situations

Boguslaw and Porter (1962) made an important distinction among the variety of system operations in which teams may engage. They described a continuum with "established" tasks at one extreme and "emergent" tasks at the other, and defined established situations as those in which relevant environmental conditions are identifiable, relevant states of the system are predictable and current technology is adequate to predict consequences of alternative actions. An emergent situation was defined as one in which the relevant environmental conditions are not identifiable, the relevant system states do not always behave according to predictions, and analytic solutions are not within the current state of the technology.

Purely established team functions are anticipated and planned for during system design while purely emergent team functions must be considered by adapting immediately to unexpected contingencies. No realistic team function is likely to be purely either established or emergent. The degree to which activities can be anticipated is a measure of the degree to which the situation may be considered established. It may still be possible to offer some degree of preparedness for emergent situations, but that preparation will be qualitatively different from the preparation possible for established situations.

Boguslaw and Porter considered team training one method of dealing with emergent situations. A number of considerations for effective training of teams in emergent contexts were discussed:

1. "Orientation to team goals" was considered important for fostering an understanding of the consequences of operator actions. "Spelling out" the team's goals allows for the formation of a more global orientation and provides a direction for actions in unexpected situations.

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2. "Training in interdependencies" was described as providing an awareness of the interdependent relations between team members. Effective team performance was described as an interaction of various member functions in which individuals have to accept the information inputs of others.

3. "Training for error analysis" emphasized the ability to recognize one's own errors so as to initiate corrective actions rather than attempt to hide their occurrences or transfer blame to someone else.

4. "Training for sensing overload" was suggested as useful for identifying when to ask for help as well as sensing when a team member is facing an overload situation and may require help.

5. "Training in adjustment mechanisms" was considered important when a team is overloaded. The methods included cueing, the ommission of some inputs, permitting certain errors, filtering, approximating, increasing the work flow channels, chunking information, or simply abandoning a hopeless situation.

Team Training Load

Morgan, Coates, Alluisi, and Kirby (1978) defined team training load as the "percentage of untrained members" in a crew. In their study of the effects of team training load on training and performance effectiveness, load was varied from 0 to 100 percent. Five-member teams were trained to perform the synthetic work presented with the Multiple-Task Performance Battery. Each team trained and worked together for 8 hours per day over 6 consecutive days. Both the acquisition of individual skills by the untrained members and team skills by the teams were assessed. The authors' results and conclusions were as follows:

1. The performance effectiveness of a team is degraded in direct proportion to the team training load — i.e., to the percentage of untrained members assigned to the team.

2. The decrement results from the poorer performances of the untrained individuals, and does not adversely affect the higher levels of performance of the trained team members.

3. The untrained team members tend to acquire the individual-performance skills at the same rate, independent of the team training load, so that all teams reach the base-line (asymptotic) levels of performance at the same time. In other words, teams with high team training loads initially suffered greater decrements in performance effectiveness, but recovered in the same training time as teams with lower team training loads, thereby giving the impression of a greater rate of recovery — this being a result of the greater number of individuals improving (because they were initially untrained), but doing so at essentially constant rates.

4. Results were essentially identical for performance measured in terms of either individual-skill or team-skill performance, with some relatively minor exceptions: (a) the team-skill performances are more resistant to decrements with the lower team training loads (below 40% untrained), but then are more seriously affected by higher team training loads (above 40% untrained), relative to the average individual-skill performance, and (b) the latter, the average individual-skill performances, are relatively unaffected by the lowest levels of team training loads (10%, possibly to as high as 20% untrained).

The authors suggested field testing for verification or modification, and although "untrained" for a laboratory may not directly translate to "untrained" in an operational context, they made tentative recommendations for the maintenance of operational combat readiness when personnel turbulence and turnover are severe:

> (a) if fewer than 10% of the (team members) are untrained, then the best strategy would be to assign the untrained persons uniformly throughout so as to minimize the proportion of untrained personnel in any one (team). . . On the other hand, (b) if the personnel turbulence and turnover between unit training opportunities is greater than 40%, then the best strategy (and probably the most cost effective) is to assign maximum numbers of untrained members to certain teams and to schedule those teams for earlier team training missions.

Alexander and Cooperband (1965), proposing that any operational definition of load will be task specific, listed some general considerations found in their review of the literature. They include event rates, input noise, number of affected sensors, number of events controlled by the responding system, information processing rate required, ratio of required time to available time for processing, number of input event classes which must be processed, and the rate at which specific operations must be performed.

Except for a notable early study by Chapman, Kennedy, Newell, and Biel (1955), an inverse relationship is almost always found between task load and team functioning.

In the Chapman Study conducted in RAND's System Research Laboratory, a "systems environment" was simulated. An attempt was made to produce a close approximation to "full-scale, real-life organizational behavior" in the laboratory. The kind and amount of equipment available to their laboratory "teams" was not varied, nor were operational policies. Task load was varied by manipulating task difficulty. As the tasks became more difficult, the crew members began to question the organization's goal, the adequacy of the equipment, and team members' competence. The crews continued, however, to operate effectively even when the task load was tripled. Crews learned to distinguish between useful and nonuseful information and focused on important events. They developed and used response shortcuts as well.

The Chapman et al. research suggested three conditions necessary to promote organizational learning: "clarify the goal, give the organization as a whole experience with tasks of increasing difficulty, and provide immediate knowledge of results."

Training Objectives

Hall and Rizzo (1975) believed that the most critical deficiency of team training is the lack of "clearly stated, definitive objectives for training to achieve." The tasks required of team members have not been carefully analyzed. Smode (reported by Hall & Rizzo, 1975) presented a suggested sequence of steps for the accomplishment of systematically derived training objectives. The steps included a description and analysis of the operational system, a definition of the task structure, the accomplishment of a task analysis, the preparation of detailed task statements, and the conversion of the task statements into training objectives.

Summary

The research reviewed converges upon the established-emergent task distinction as a critical consideration in the training of teams. Whether or not conditions can be anticipated and prepared for has an obvious impact on what should, or even can, be trained. Established situations suggest training in procedures and policy. More emergent situations suggest training in decision making and perhaps instruction in what not to do in certain potential circumstances. Certainly, the considerations proposed by Boguslaw and Porter (1962) for effective team training in emergent contexts deserve closer investigation.

Team load appears to be a measure of task difficulty, whether the difficulty is a function of the number of less than optimally trained team members or the task specific factors listed by Alexander and Cooperband (1965).

The notable exception to the inverse relationship generally found between task load and team effectiveness found by Chapman et al. (1955) may be related to their attempted creation of a "full-scale, real-life organizational" atmosphere. Their suggestions for the promotion of organizational learning appear to have merit.

The importance of adequate training objectives has long been recognized in the educational psychology literature and should not be overlooked in the conduct of training for teams.

V. TEAM CHARACTERISTICS

Organization and Structure

Team tasks may be organized in "series" or in "parallel." Series tasks are constructed such that all relevant individual responses must be performed at acceptable criterion levels for a task to be considered successfully completed. The parallel task structure considers a response correct if responses by one or more members of the team are appropriate. Klaus and Glaser (1968) used this distinction as one criterion for differentiating between a team (series) and a small group (parallel).

The nature of the task and its interdependency on other tasks will greatly impact how the team will be organized. The organizational variability that can be manipulated, however, can influence team output (Meister, 1976). Briggs and Johnston (1967), for example, recommended a hierarchical structure for the organization of teams. This organizational structure allowed the team decision maker more control over the flow and exchange of data among the members and minimized information-processing capacity limitations.

Kennedy (1962) conceptualized the cooperative human organization as a kind of "synthetic organism" in which individuals become components or organs of a different entity. Temporal processes (growth and development) are the outstanding aspects of the organismic view of a team, and performance effectiveness is a function of level of development (Alexander & Cooperband, 1965). The process of adaptation by the team to the emergent characteristics of its environment accounts for increased performance effectiveness. The emphasis is on cognitive aspects of learning. If this concept of the team as a developing organism is adopted, the objective of team training would be to raise the team performance level by raising the level of team development. The types of questions to be answered in a research program oriented toward the synthetic organism point-of-view would include:

1. What kind of behavior can be expected at various stages of development?

2. How can these stages be recognized and measured?

3. What processes underlie changes in team behavior?

4. How are these stages of development and their representative behaviors related to team performance?

5. What manipulatable factors affect the rate and level of development of the team?

Morrissette, Hornseth, and Shellar (1975) investigated the effects of two conditions of team organization (division of labor versus redundancy) on the detection of randomly presented signals shown on circular display windows. Under the division of labor arrangement, each member of a two-man team assumed responsibility for signal detection on different display screens. The redundancy arrangement members each monitored all displays. Redundancy provided a back-up capability which reduced the probability of non-detection of signals whereas division of labor reduced individual team member workload. Long detection times were found under the division of labor team organization but not under the redundancy arrangement. The authors concluded that for the type of monitoring task used, a redundant team arrangement was considered more effective.

Cooperation

In the United States, it is generally assumed that the spirit of competition is the best atmosphere for progress. Haines (1965) took exception and drew an illustrative contrast between the concepts of competition and cooperation which was based on the early definitions and findings of Deutsch (1949a, 1949b). Cooperative situations were described as "promotively interdependent" with respect to goals, in that the movement of any individual toward a goal increases the possibility of other team members reaching that goal. Competitive situations were seen as "contriently interdependent," in that the movement of any individual toward a goal decreases the possibility of other members of the team reaching the goal. Competition was seen as a corrosive, destructive force while cooperation was viewed as lending itself to a positive state of group feeling. Cooperation was also viewed as promoting both verbal and nonverbal communications leading to a closer feeling of group involvement.

With respect to cooperation, Alexander and Cooperband (1965) described it as "learning the strengths and weaknesses of one another, learning when the others want help and when they do not want it, learning to pace one's activities to fit the needs of all, and learning to behave so that one's actions are not ambiguous."

McRae (1966) believed that the effectiveness of small combat teams (U.S. Army) is a function of the degree to which team members cooperate and coordinate their efforts. The objective of the study was "to discover and apply principles for the design of team training that will increase team cohesion and efficiency. . . and to test whether such training will affect the individual's behavior when he is assigned to a team other than the one in which he was trained." In an attempt to train the desired behaviors, team members were required (a) to attend both to what other members were doing and to the impact of their behavior on the group task, (b) to communicate relevant observations and suggestions to other members, and (c) to perform the function of other members who were overloaded. The information to be extracted involved the relationships between the interaction of a working team and its effectiveness. The task was a group maze problem that could be solved only by verbal interaction of all team members. It was found that information exchange about specific aspects of the task was positively related to team effectiveness. Information exchange about team procedures or organization did not produce the same beneficial results. The data also suggested that more interaction was required for more difficult tasks.

Coordination

Crew coordination may be defined from two different perspectives: as a synchronization of action within a group, or as the improvisation of responses among group members to meet situational contingencies (Hood, Krumm, O'Sullivan, Buckhout, Cane, Cotterman, & Rockway, 1960):

> A group of persons or objects, working to fulfill a common purpose, are said to be coordinated when they behave as required within a time scheme or cycle. . . All coordination activities are listed as standard operation procedures (SOP), and all formalized crew procedures are essentially of this type. . . Crew coordination may also be viewed as a measure of the extent to which individuals participate effectively in solving problems for which a stock answer is not available to the crew as such.

The essential characteristics of the latter type of crew coordination were listed by Hood et al. (1960):

> 1. Each team member identifies and shares the group problem and objective in addition to his own responsibilities.
> 2. Each team member responds at least partly as a function of the responses he observes other team members make.
> 3. Each team member pays attention to the responses made by at least one other team member with respect to the team objective as reflected in the second team member's responsibilities and output.

Team coordination may take different forms as a function of the context in which it is required. A relevant distinction within the team training context is coordination within established vs. emergent situations. "In the established situation, events are repetitive and predictable and there are specified and detailed rules for handling them" (Hall & Rizzo, 1975). Coordination may also result from planned and executed individual acts. In this context, the individual skill attainment is an important ingredient and effectiveness may be viewed as the sum of the individual proficiencies. An example is the performance of a symphony orchestra following sheet music and coordinated by a conductor.

"In the emergent situation, events are unpredictable and there may be more than one equally good solution to a problem." Coordination is a product of member interaction with improvisation and impromptu response generation. Individual skill remains important, but rigid formats are not adhered to and the end product may be more than the sum of individual skills. This situation is exemplified by a jazz ensemble which performs relatively free-form with variations naturally emerging.

In examining crew interaction and coordination, Hood et al. (1960), reported a series of tests given to B-52 crew subteams. An Operating Procedures Test was administered to measure awareness of the "who" and "when" aspects of task accomplishment. An Academic Cross-Knowledge Test was given as a measure of knowledge of "who does what" in a crew. A Leader Behavior Description Questionnaire concerned with aircraft commander traits of "consideration" and "initiating structure" was given to assess the relationship with crew proficiency. Finally, an Attitude Inventory was included to assess crew members' attitudes toward the Air Force, toward their specific job assignment, and toward other members of their crew. A fair synopsis of the findings on the manner in which crew coordination developed follows:

> In the absence of specific rules regarding standard operating procedures, crews will tend to develop their own procedures. These will be similar in most instances (because of equipment location and crew training), although inexperienced crews will tend to develop ways of accomplishing tasks that are unlike those used by more seasoned crews. As crew members gain experience in flying together, their attitudes toward each other are

modified to become more accepting. Simultaneous with
this attitude modification there develops an increase in
flexibility. Crew interaction is increased to the point
where, depending upon circumstances existing at the
moment, there is an interchange of responsibilities.

Crews with less total flying experience seem to indicate a
certain rigidity in accomplishing tasks, in the sense that
there is a reliance on more fixed operating procedures. As
these crews gain experience, they either discover for
themselves improved ways of accomplishing tasks, or they
learn these from discussions with other crews. In either
event, they conform to methods used by the majority of
crews.

As weapon systems began to require more sophisticated training devices to realistically simulate
operational problem situations, operators were required to pace or sequence their activities with other
operators. As complex as training devices and simulators were at that time, they provided for the
simultaneous training of no more than two operators.

Krumm (1959) reported an early assessment of the value of linking simulators or training devices for
the purpose of promoting crew coordination. The devices electronically coupled were the B-52 Flight
Simulator and the T-2A Radar Trainer which allowed two pilots and two navigators practice on a wide
range of tasks which required coordination. During simulator flight checks, items were selected in terms
of their orientation to individual proficiency or to crew coordination activities.

The author concluded that proper use of integrated flight simulators did result in an appreciable
improvement in crew skills even though statistically significant differences in crew coordination skills
were not found for the pilot groups and only slight, but significant, differences were found for the
navigator groups. The lack of practically significant differences was attributed to the fact that the crews
had received all of their aerial instruction before the final simulator test was given. Any differences as a
result of the integrated simulator missions could have been neutralized during the aerial missions.

Research reviewed by Collins (1977) indicated that the development of coordinative skills is
important to team members' "knowing what to do, when to do it, and particularly why they should take
particular actions." He summarized the concepts believed to foster the development of coordinative skills
to include "an awareness of the total system by each member and the relationship of his task to all other
tasks, and understanding of the characteristics and functioning of the environment and the relative
importance of various events, and the development of innovations for better organizing team activities."

Communication

Glaser and Glanzer (1955) broadly referred to communication within the team structure as "all
interaction between team members and between the team and the environment that is necessary for
accomplishing a task." Communication outputs from one individual serve as inputs for other team
members. These communication "links" were analyzed to describe team operations and 14 descriptive
variables were identified:

1. "Link frequency" referred to the number of communication links over which the members of a
team communicated and was considered an indication of the complexity of the team's communication
structure.

2. "Communication frequency" concerned the extent to which links were used and was considered a
measure of team activeness.

3. "Councurrent activity" was a measure of the extent to which team members all acted at the same time which controlled the availability of team members to take on additional responsibilities during busy periods or during a reduction of personnel.

4. "Process differentiation" was a categorization of tasks in terms of a number of classes of activities and was considered a measure of the type of team (i.e., observing type versus decision making type).

5. "Input magnitude" referred to the complexity of input stimuli and described the extent to which the team handled several simultaneous inputs.

6. "Sequence predictability" reflected the extent to which team functioning could be predicted on the basis of preceding acts. High predictability was considered to lead to fewer operating errors.

7. "Intra-team dependence" concerned the extent to which team inputs were generated by other team members and was considered a measure of team self-containment which was believed to lead to better team control.

8. "Communication media" implied different problems with reliability and different training requirements.

9. "Communication signifiance" referred to the processing and integration of messages by a control individual on the basis of relevance to the team goals.

10. "Output irrevocability" described the extent to which a team output could not be corrected or changed, once made.

11. "Anticipatory cuing" referred to clues in a sequence of activities which came from activities several steps earlier and served a preparatory function.

12. "Urgency" was a measure of the speed and pressure requirements under which team operations took place.

13. "Saturation" considered the likelihood that external inputs could occur at a greater rate than could be adequately handled.

14. "Supervisory and emergency ratio" described the inclusion of a supervisory structure and its usefulness in emergency situations.

Radio communications between ground controllers and pilots were investigated via simulation by Loftus, Dark, and Williams (1979). It was hypothesized that processing appropriately with controller-issued instructions could, under certain conditions, heavily tax a pilot's memory. Frequent problems were expected to occur when (a) a controller message contained more than one instruction and (b) it was necessary to perform some kind of distracting activity between the time an instruction was issued and the time that the instruction was acted upon. The manner of encoding numerical information was also varied.

The major results were predictable from theories of basic human information processing. Much of the variance appeared to be accounted for by what kind of information was being recalled. Place information was remembered well, frequency information was remembered relatively poorly, and memory for code information fell in between. The number of messages that the subject was required to remember had a large effect on the probability of responding correctly to any one message. Forgetting occurred over an interval of 15 seconds following message reception and the encoding scheme accounted for a relatively small, but reliable, amount of the variance.

Irrelevant (non-required) communications were reported by Meister (1976) to have a negative effect on team performance. Air Defense operator performance assessments indicated that a portion of communicative exchanges were social in nature and contributed only to changes in morale. It was recommended that team communications be minimized except when required information could be secured only in that way.

Meister further reported from his examination of the literature that visual communicaton meth. ds were more effective than verbal communications in aerial intercept studies conducted at Ohio State University. Teams trained with visual channels alone performed as well as those trained with both visual and verbal channels.

Differences in team performance were also reported as a function of both communication structure and communication pattern (Meister, 1976). A structure which permitted more direct transmission of information was preferable and the pattern of messages changed as a function of both training and task characteristics, but the practical significance of these changes was elusive.

Team Composition

Meister (1976), in discussing team composition, first distinguished it from team organization by specifying that composition factors do not vary when the individual moves from one team to another while organizational factors are related to the way individuals are used in a given team.

Personality variables were emphasized as a contributor to those team member behaviors that were not considered system outputs. The literature reported by Meister suggested that team composition on the basis of member personal preferences fostered more achievement and job satisfaction In contrast, heterogeneous groups were found to produce a higher proportion of high quality solutions. Heterogeneity, in terms of ability, was also found to produce superior performance. Task factors appeared to be the driving condition. It was suggested that heterogeneity is desirable in problem-solving groups as each member brings different resources to address the problem. Homogeneity was considered advantageous with non-cognitive tasks requiring cooperation as homogeneity may be more conducive to coordination activities.

Size/Decision Rule

The effects of team size and the "decision rule" used to define what was meant by a "team response" were investigated by Waag and Halcomb (1972). Team size varied from two to five members each. The decision rule was either a parallel arrangement in which the team response could be produced by any one or more of the team members, or it was a series arrangement in which the team response was produced by the combined responses of all team members. The task required the monitoring of a visual display in order to detect aperiodic signals which occurred against a background of discrete regularly occurring events. As team size increased, detection performance increased inuependent of the decision rule employed. As the decision rule moved along the continuum from purely parallel (requiring only one team member to respond) to a five-member series arrangement (requiring all five members to correctly respond), detection performance deteriorated. Along with an observed maximization of detection performance with parallel teams, a greater number of false positives were also found. These false hits increased as a function of team size. Under the series arrangement, false alarms were completely eliminated. Rules derived by the authors included the use of the parallel decision rule when one is interested primarily in increasing the number of correct detections, the use of the series decision rule when the interest is in minimizing false alarms, and duplication of team members if the goal is to minimize total errors.

Meister (1976) reviewed the relationship between team size and team performance. He reports that teams solved problems more rapidly and correctly than individuals, but not proportionately so. If the team performance output was described in units per individual, the advantages of multi-individual groups became less apparent. This may have resulted, in the team condition, from a diversion away from the primary task toward integrative and coordinative behaviors. Meister concluded that the nature of the task performed is probably the crucial factor in determining the significance of team size.

Summary

It is unlikely that the organization and structure of "real-life" operational teams is flexible enough to allow serious study of this variable. Any attempt to study organization and structure by altering it in any context other than a fully independent simulation is likely to meet with considerable resistance by nature of the obtrusiveness of the research. A fully independent simulation of team training is questionable at this point by virtue of the uncertainty about which variables should be included for effective transfer.

Cooperation, coordination, and communication deserve serious consideration as significant parameters in the training of teams. Particular emphasis should be directed to these characteristics in emergent contexts. Considerable evidence has been collected which suggests that these may be the qualities which cause team output in emergent situations to constitute more than the sum of individual inputs.

Team composition variables may be defined as collective individual characteristics and learner strategies and could be considered the interaction of these individual properties. The value of team composition, then, may be regarded as a reflection of the effectiveness of various combinations of the individual characteristics and strategies discussed earlier.

Adding members to a team in a parallel arrangement appears to have merit for critical tasks. The excess manpower and additional expense are warranted in situations where an error may have grave consequences.

For non-critical tasks, an effort should be made toward the "optimum" team size — that which allows maximum efficiency with a minimum drain of resources.

VI. KNOWLEDGE OF RESULTS

Team Feedback

Knowledge of results, while considered fundamental in the learning process, leads to some unique problems within complex team training environments. Three considerations listed by Alexander and Cooperband (1965) form the context from which these problems emerge. They include the vagueness and difficulty of objectively specifying criteria for effective team performance and the probability that team skills require different feedback procedures than do equally important individual skills and that the two forms of feedback may interface with one another.

The following series of studies performed at the American Institutes for Research contain many of the considerations discussed earlier in this review. They are reported here as a unit because the orientation of each is toward knowledge of results and a relative disregard for the individual contributions within a team.

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Klaus and Glaser (1960, 1968, 1970), as part of activities performed at the American Institutes for Research Team Training Laboratory, adopted a view of the team as a "single response unit" having performance characteristics that respond to operant conditioning techniques much as an individual responds.

This view by Klaus and Glaser (1960) of the team as a "modular unit having performance characteristics which can be effectively influenced to provide higher and higher levels of proficiency" was a conceptualization of team performance with three basic assumptions. The first was that the teams's output depends on defined member inputs. The second was that the team itself can be considered a unit of investigation with manipulatable responses independent of individual performances. The third assumption allowed that team performance varies with the consequences of team responses just as individual performances vary with individual consequences.

Based upon these assumptions, a program of research was instituted to measure the team response to various reinforcement contingencies (Egerman, Glaser, & Klaus, 1963; Egerman, Klaus, & Glaser, 1962; Glaser, Klaus, & Egerman, 1962; Klaus & Glaser, 1960, 1965, 1968; Klaus, Grant, & Glaser, 1965; Short, Cotton, & Klaus, 1968).

The acquisition and extinction of a team response was investigated (Glaser, Klaus, & Egerman, 1962; Klaus & Glaser, 1968) and the data yielded performance curves very similar to those that would be expected from studies of individual behavior. The team response demonstrated positively accelerated response acquisition curves; negatively accelerated extinction curves; spontaneous recovery; and savings in terms of response reacquisition. Of particular interest was the observation that individual proficiencies appeared to remain constant concurrent with improvements in the team as a unit.

In a continuation of the Team Training Laboratory's investigations, the effects of adding an additional member to a team were assessed. The added member served in a parallel mode with an existing team member such that a correct individual response by either member contributed to a correct team response (Egerman, Klaus, & Glaser, 1962). Adding redundancy to a team was found to produce a detrimental effect on team performance. With the parallel arrangement, one member could perform incorrectly and if the parallel member performed correctly, the incorrect member's inappropriate behavior would be reinforced because of the correct team response.

Egerman, Glaser, and Klaus (1963) further investigated the effects of team organization using three two-member team arrangements. The series and parallel arrangements were used, and an "individual" team arrangement was added, in which one pre-selected team member's performance was reinforced. The series teams showed slight improvement over performance trials. Parallel teams, however, showed a 13% decline in performance proficiency. The members of the individual teams, upon whose performance team output depended, showed slight increases in proficiency while the other team members showed a 26% reduction in proficiency as a function of reinforcement for both correct and incorrect performance.

The fifth report in this series (Klaus & Glaser, 1965) reported on team learning as a function of member learning characteristics and practice conditions. Three-member teams were composed of individuals of low, medium, or high proficiencies based on performance during individual training. The teams were further differentiated on learning ability (fast versus slow learners), delay in the initiation of team training following individual training, and homogeneity of individual proficiency within teams. The primary findings of this study suggested that it was "individual member proficiency, or level of attainment, and not member learning ability which was predictive of team acquisition rates." And further, that "team acquisition was a direct function of the conditions and schedule of team reinforcement during team training as determined by the probability of a correct team response."

The remaining two reports in the American Institutes for Research series investigated supervisory furnished reinforcement and the simulation of team environments (Klaus, Grant, & Glaser, 1965; Short, Cotton, & Klaus, 1968). Added reinforcement by a team supervisor had as its purpose the maintenance of individual proficiencies despite a lack of team success or as a supplement to individual reinforcement in the case of a correct team output. The combined use of team and individual reinforcement did lead to more rapid development of team proficiency, but was interpreted as functionally no more valuable than additional practice.

Short, Cotton, and Klaus (1968) studied the potential advantages of simulating the team setting as a learning environment for a single individual. Three studies "concerned with diminishing the effects of a reduction in the frequency of reinforcement attributable to team formation" demonstrated that it was possible to "simulate the key conditions of team training with only one subject and that simulated environments are conducive to the study of factors affecting the development and maintenance of a team response" (Klaus & Glaser, 1968). Accurate simulation of team environments was seen by Klaus and Glaser (1968) as producing three advantages. They included a more replicable stimulus environment leading to better isolation of main effects, a reduction in research costs due to apparatus and/or the inclusion of larger and more complex teams for investigation, and a way of determining when sufficient information has been collected by observing when the simulated teams begin to perform similarly to the regular teams in the laboratory.

The effects of individual versus team performance feedback on a perceptual motor task were studied by Nebeker, Dockstader, and Vickers (1975). Individual versus team feedback and raw score versus percentile versus no feedback were varied. The authors hypothesized that the effects of feedback would be more pronounced when directed to the individual as opposed to the group. They also predicted that feedback effects would be additive in that the combination of group and individual feedback was expected to produce higher performance levels than either alone. It was additionally hypothesized that percentile feedback, by virtue of its comparison value, would increase the positive effects of feedback.

Being identified as a team member did not, of itself, increase or sustain performance when effects of feedback were controlled. Individual feedback was not found to be more effective than group feedback and the effect of providing both types of feedback did not significantly improve performance. The results also indicated that individuals do perform better with feedback than without, but that it did not matter whether the feedback was in percentile or raw score form..

A possible explanation for the lack of positive findings was in the type of group construction used. The groups were not constructed to emphasize greater interdependence and coordination. The interdependence in this study was limited to that accrued through summed group output and no rewards were offered as inducements to perform.

Team Consensus Feedback

The effectiveness of providing "team consensus feedback" to Army surveillance image interpreters was investigated by Cockrell (1968). Based upon the following two general principles, five feedback conditions and a control were varied: (1) If multiple image interpreters independently arrive at the same identification, the identification carries a high probability of being correct, and (2) Interpreters who discuss conflicting identifications often resolve the conflict by agreeing upon the correct identification.

A "serial consensus" feedback condition involved three-member teams in which members identified different images and then traded seats in order to check the work of their teammates. A discussion phase followed, and a team determination was made by majority vote. An "immediate consensus" feedback condition required examination of the same image by all three team members. Individual results were overlayed and compared with the final determination again made by majority vote. A "delayed

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consensus" feedback condition was similar to the immediate condition except that three different images were evaluated by each team member before the discussion and consensus judgment. A "precise team feedback" condition was similar to the immediate condition except that the tern was provided with correct location and identification information following each team determination. A "precise individual feedback" condition required all interpreters to perform as individuals and correct information was provided as feedback. In the control condition, all interpreters worked as individuals, and no feedback was provided.

The primary results are listed below:

1. Interpreters working in teams with consensus feedback showed greater overall improvement in performance than did interpreters working alone with no feedback.

2. The consensus feedback methods in which interpreters checked their teammates' reports after each image determination resulted in greater average gain in proficiency than consensus feedback after multiple determinations.

3. The precise feedback methods resulted in the greatest average gain in interpreter proficiency.

4. Differences among the experimental methods were attributable to improvements in target identification rather than to improvements in target detection.

The major hypothesis of the study predicted that "individuals working in teams with consensus feedback would improve more in performance than individuals working alone with no feedback" and was confirmed. As a method of maintaining proficiency, the team consensus method also appeared to have merit.

Four follow-on experiments were reported by Cockrell and Sadacca (1971) in which the team consensus feedback method was further investigated as a technique for maintaining and enhancing the proficiency of image interpreters working with surveillance systems. The use of team consensus feedback again resulted in performance improvements over a control team operating individually with no feedback. The greatest improvement was again in the area of target identification although reductions in the number of false alarms were also found. Low proficiency interpreters showed the most significant gains and interpreters assigned to teams that were heterogeneous in terms of proficiency achieved greater gains than did members of homogeneously constructed teams. The results suggested that low proficiency operators gained through their collaboration with more efficient operators. There was no evidence of a main effect of team discussion or team size.

Contrived Feedback

Team output is more apparent, and therefore easier to assess, than is individual output within a team context. Consequently, team members are generally more likely to receive team feedback than individual feedback regarding their individual levels of performance. In a study by Johnston (1967), team feedback was fabricated by instructing subjects that they had a partner in a tracking task and that post-trial feedback represented a team score relative to average tracking performance. The feedback provided actually represented that particular subject's performance relative to a "manipulated criterion" which effectively varied the levels of "team feedback."

The subjects accepted credit for good performances (often solely a function of a lenient criterion) and blamed poor performance (actually due to a more stringent criterion) on their contrived partners. The results were interpreted in support of team feedback as a determinant of individual behavior motivated by a desire, on the part of the individual, to produce above-average performance.

The identification and correction of individual errors was cited by Hall and Rizzo (1975) as a major source of difficulty in team training. The value of providing error information as feedback was not questioned in established situations, but in more emergent-type situations, it was hypothesized that error information might perpetuate the procedure used. In complex team tasks, there may be more than one correct procedure. If a particular solution generates feedback confirming it as correct, the likelihood of that solution being applied in subsequent similar situations is likely to increase with a corresponding decrease in the probability that other correct (and perhaps better) solutions will be selected. The authors suggested that "training scenarios should be analyzed to determine critical procedures, decision points, communications, and coordinated activities which may be directly or indirectly linked to the mission outcome. . . . A feedback schedule may then be established for critical mission events."

Summary

The types of feedback provided (individual or group) certainly vary with the model of the team employed. If the team is viewed as an organismic entity, then group feedback is appropriate. If the individual contributions of team members are considered more important, then individual feedback is more important. If the opinion is that a team is some combination of both, then a combination of group and individual feedback commensurate with their relative contributions to team output seems appropriate.

There seems to be little dispute that individual competency is important no matter which model is employed. A feedback schedule which develops individual proficiency with individual feedback and team proficiency with a combination of group and individual feedbacks seems viable. A combination of both feedback types in the team environment follows from an assumption that the individual must still perform to some minimal level so as not to decrease team efficiency.

VII. PERFORMANCE OBJECTIVES/MEASUREMENT/EVALUATION

Performance objectives, to be maximally useful, should be operationally defined and derived from a deliberate series of steps. They should also form the basis for performance measurement. Wagner et al. (1977) described three characteristics of a "systems approach to training development." The objectives must describe behaviors that will be performed in the test situation, should specify the conditions under which these behaviors will be performed, and should include performance criteria.

With respect to aircrews, the goal of performance measurement was described by Vreuls and Wooldridge (1977) as the provision of information capable of guiding many different kinds of decisions. In order to provide the necessary information, measurement should have "demonstrated diagnostic power and validity." The authors' position held that adequate diagnostic measurement would have to include measures of basic abilities, subject matter knowledge, past performance, and current task performance. Two methods were described for deriving the measurement samples needed: (a) measure "everything that moves" at the onset and later decide what is important, or (b) initially reduce all possible measures to a smaller set of measure candidates by some method other than empirical data collection and test that smaller set in order to establish final measures and formats. Measuring "everything that moves" is neither cost-effective nor practical and the greater proportion of flight task variability has been accounted for by fewer than 15 variables (Vreuls & Wooldridge, 1977).

The approach for development of performance measurement recommended by Vreuls and Wooldridge was described in five steps. A measurement analysis step, a design and development of the 1st data acquisition system step, a data collection step, a statistical analysis step to select important measures and interrelationships for describing and diagnosing performance, and a utility test step.

Although derived from an aircrew environment, the following generalizations offered by Vreuls and Wooldridge are assumed to be applicable to command, control, and communication environments as well. The keys to good flight performance measurement were described as including adequate sampling of generally generic decisional, procedural, mission-related, and perceptual-motor skills; clear definition of the time frame for observations; clear delineation of the boundaries of desired performance; use of the fewest reliable data points necessary to compare actual to desired performance; and considerations of different information formats which are responsive to the needs, capacities, and limitations of the operator.

Glanzer, Glaser, and Klaus (1956) developed a Team Performance Record as a formal procedure for the overall description, analysis, and evaluation of team performance. The requirements for the procedure included clearness and explicitness as to the nature of the behavior to be recorded and a close relationship to the kind of behavior which actually appears in team of the type being observed. Nineteen categories were initially developed representing critical factors in the performance of Navy teams in general. Within each category, effective behaviors and ineffective behaviors of observed incidents were noted. The final general Team Performance Record consisted of 13 critical areas of team performance based on a wide range of ships, personnel, functions, types of teams, and types of problems. These critical areas were (a) availability and readiness of equipment and materials, (b) composition of group and assignment of members, (c) briefing and preparation of personnel, (d) interest and morale, (e) safety precautions, (f) communication procedures and coordination of information, (g) knowledge of equipment and its operation, (h) knowledge and performance of individual duties, (i) judgment and planning, (j) checking and monitoring, (k) supervision and leadership, (l) interchangeability and assistance among team members, and (m) performance in emergencies and damage control.

The Team Performance Record was found to be an effective tool for the "systematic observation, recording, and evaluation of actions which are either outstandingly effective or ineffective with respect to the accomplishment of the team task." The procedure stressed a particular incident rather than a generalization about the team or a team member. Through use of the record forms, changes in performance or newly developed problems were highlighted for consideration in training. The observer's attention was directed, by use of the instrument, to the critical aspects of team performance and away from less significant ones. As a result, the recording of incidents centered on actions which were critical to team operations.

The evaluation of complex behaviors such as those found within the interacting interrelationships of team behavior is a difficult task. Conceptually, performance measurement and evaluation are functions of the view of teams held. If the team is considered as an organismic entity, performance measurement will probably focus on the team product and the quality of that performance will be judged in terms of the quality of the team output. If the team's performance is viewed as a collection of individual contributions, then performance measurement will usually consider some combination of individual proficiencies (Hall, 1976).

In the process of investigating the techniques and concepts involved in providing detailed measures of team, subteam, and individual performance, Yaeger and Bell (1977) pointed out that useful measures should be selected for their ability to eliminate redundant information, their sensitivity to skill changes, and their performance prediction qualities. The authors cautioned against the unsystematic, and often inappropriate, application of performance measures and pointed to a need to further develop a performance measurement methodology for team training.

Summary

Adequate team performance measurement is obviously essential in any long-term research and development effort with the goal of producing an improved technology for team training. The team

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performance measurement area is not yet well defined and to some degree reflects the ambiguities associated with the definition of the team itself, team behaviors, and team functions.

Wagner et al. (1977), Vruels and Wooldridge (1977), and Yaeger and Bell (1977) have discussed the essential characteristics of an effective performance measurement systems for teams. A comprehensive effort to develop an adequate measurement system that incorporates many of the criteria suggested in the previous discussion needs to be undertaken before systematic experimentation can be conducted in the area. Such an effort would be considerable in its scope and rests on an adequate definition of team behaviors as a necessary foundation.

Of particular note and interest in field data collection efforts is the Team Performance Record developed by Glanzer et al. (1956). The Record could be used as a potential starting place for the development of specific field data collection instruments that reflect the specific objectives of a given effort. Although the Record was initially developed for application to Naval teams, the critical areas it includes suggest a number of team functions that must be evaluated when assessing the adequacy and comprehensiveness of any team training program.

VIII. INSTRUCTIONAL SYSTEM DEVELOPMENT

The instructional system approach to flight crew training holds that training requirements must be defined by consideration of the characteristics of required human tasks. Rather than resort to a "teach everything" posture using all available system information, a distinction is made toward necessary, "need to know" content for training. Wallis, Ewart, and Kaufman (1966) described the instructional system approach to training as "requiring a formal decision-making procedure leading to a strategy of (flight) training which is relatively complete, forms a closed loop, and can provide maximum effectiveness at minimum cost." The authors delineated five functions necessary to this approach to training:

1. A formal acknowledgement of initial requirements. An early definition of the purpose and requirements of the effort are demanded by definition of the end product.

2. A breakdown of the system into manageable, functional subsystems. The context of the overall system should not be lost.

3. A consideration of the nature of the individual and the individual's capabilities. The nature of the individual knowledge acquired, and the nature of the task are factors in this function.

4. A derivation of tasks and assignment to subsystems for required training. This function combines the individual, knowledge acquired, the machine, its design, and its purpose. From this combination the required, precise training requirements are synthesized.

5. A translation of the combination of operator and machine properties into course outlines by a process of methods/media selection.

Wallis, Ewart, and Kaufman contended that basically two functions have to be trained: skill and knowledge. The purpose of their approach to ISD was not to teach individuals to fly, but to train them to effectively operate the system. The difference was described as an ability to do (skill) versus an acquired memory of facts (knowledge). The instructional system approach was interpreted as a vehicle for formalizing decisions on the knowledge level.

In presenting a state-of-the-art assessment of instructional strategies for computerized collective training for teams (COLT^2), Kribs, Thurmond, and Mark (1977) concluded that an ISD approach to team training has yet to be developed. The authors supported the approach that such a strategy should consider (a) team task dimensions and team training objectives, (b) learner characteristics and strategies, and (c) characteristics of the training delivery system used to implement the strategies. Team task dimensions included self-evaluation, team awareness, team attitudes, communication, and decision making. Team task analysis included considerations of a system block analysis, task-time charts, functional task descriptions, and behavioral details descriptions. The learner characteristics considered were intellectual aptitude and availability of strategy skills, personality variables, cognitive styles, perception preferences, and motivation, sex, and prior knowledge variables. Learner strategies included comprehension strategies, memory strategies, and problem solving strategies. The training delivery system considerations addressed computer-assisted instruction capabilities.

Kribs, Thurmond, and Mark, as well as others (e.g., Collins, 1977; Faust, 1976), have noted that a "total system approach to the design, development, and evaluation of team training is required." It was suggested that a systematic approach to team training ISD should start with a team task analysis which includes a definition of observable outcomes, a specification of task conditions and a determination of performance criteria.

Thurmond and Kribs (1978) designed and implemented a team ISD model for the purpose of developing training materials for the Army Research Institute for the Behavioral and Social Sciences. The purpose of their investigation was to demonstrate and evaluate a computer-assisted instruction (CAI) "brassboard" for computerized, collective training for teams (COLT^2). The major components of the team ISD approach included job/task analysis, development of team learning objectives, and scenario development, inclusive of instructional strategies.

The ISD model employed by Thurmond and Kribs was reported by the authors to contain some notable strengths and weaknesses:

> Foremost among its strengths was the efficacy of implementing the job/task and training analysis. The analysis methodology. . . yielded discrete tasks. . . with both situational context and team structure dimensions identified. The job/task flowcharts developed from this analysis also proved exceptionally efficient as vehicles for translating the job/task and training analysis into training scenarios reflecting not only the task to be performed, but also the environmental conditions to be simulated.

> The weaknesses of the team ISD model were in two directly related areas. First, a distinct deficiency of the model was revealed in the formulation of team learning objectives. The model lacks the methodology for preparing terminal and enabling objectives and analyzing the objectives by learning category. This deficiency is also related to the lack of evaluation procedures in the model. More specifically, evaluation of the member acquisition of team skills (i.e., coordinating and cooperative behaviors) is not present.

Eggemeier and Cream (1978) described a task analytic technique which was developed to overcome two major weaknesses of traditional ISD processes: "the lack of sufficient specificity for actual design of training devices and the lack of an adequate means to address the design of a device for team or crew coordination training." The solution to these problems involved providing only the levels of fidelity that were necessary to accomplish specific training objectives. A brief description of the technique follows:

The training device design technique is based upon the use of behavioral data in a development process which involves the intended users of the training device, training psychologists, and simulation engineers. A basic objective of the technique is to provide a description of the training requirements that are to be accomplished in the training device. Training requirements are expressed in behavioral terms. These requirements are eventually translated into training device requirements. The user serves as a subject-matter expert in identifying the initial set of training requirements. The user also participates in the iterative process which is involved in translating training requirements into device requirements. The training psychologist is responsible for developing and coordinating inputs from the user. The psychologist also serves as the interface between the user and the simulation engineer. The engineer is responsible for implementing the training requirements and producing a design specification capable of satisfying the requirements.

The technique described has been successfully used in a number of applications, including the design of a team training device for members of the fire control team of the AC-130E Gunship.

Summary

Several investigators (e.g., Collins, 1977; Faust, 1976; Thurmond & Kribs, 1978) have noted the lack of an adequate ISD methodology for development of team training programs. Current ISD technology (e.g., AF Pamphlet 50-58) does not include means for adequate identification and consideration of team training requirements, but rather focuses on identification of individual training requirements. An essential step in improvement of current team training technology is development of a systematic approach to team training program development. An essential first step in development of such a methodology is a technique or means for identification and adequate description of team behaviors and team requirements.

Development of a comprehensive ISD model for team training also rests to a considerable degree with several of the other research areas discussed previously. Data pertaining to such areas as suggested sequencing of individual and team skill acquisition, team performance measurement, team versus individual knowledge of results, and the impact of team and task characteristics on choice of instructional strategy are required in order to formulate comprehensive training program design guidance.

As an initial and manageable first step in an effort to develop a team training systems methodology, high priority should be given to the development of adequate task or function analytic techniques for identification and description of team training requirements.

IX. CONCLUSIONS

Despite the large amount of research conducted in the team training area to date, major issues remain in each of the areas discussed in this review. As indicated previously, the team training area is very significant to the Armed Forces in terms of the manpower and monetary resources that are expended each year in such training. More importantly, the team training area is an essential one in maintaining critical proficiency among various types of operational units. For these reasons, it is critical that the issues noted throughout this review be resolved.

The thrust toward team training rests on the assumption that team output is something more than the sum of individual outputs and that some distinctive elements determine team effectiveness and efficiency.

It is these unique elements that are the focus of team training. Unfortunately, the identification, quantification, application, measurement, and evaluation of these elements have proven quite elusive. Perhaps this is why "teamwork is ordinarily taught not in terms of the acquisition of specific qualities or skills, but by providing the operator with an opportunity to practice individual skills in a team context" (Meister, 1976). A clear opportunity to realize high potential payoffs exists with the development of measurement and assessment techniques for team outputs.

Teams almost certainly function on a continuum between established and emergent situations. It appears that the stimulus-response model is more appropriate toward the established end of the continuum, while the organismic model finds more application in emergent contexts. Wagner et al. (1977) offered the following general conclusions which transcend the conceptual and methodological differences between the two models: (1) Where interactive skills are required, team training is a necessary addition to individual training. (2) Individual skill competencies are a necessary prerequisite to effective team training. (3) Initial skill acquisition should not be taught in the team context, and (4) Performance feedback is critical to both individual and team skill acquisition.

The application of ISD to the development of team training holds promise for the identification of the interaction, communication, coordination, decision making, composition, structure, and other (perhaps as yet unidentified) team performance variables. There is an awareness that the objectives identified should be treated with the appropriate measurement and evaluation tools. Simulation and computer technologies encourage imaginative and creative approaches to the identification and treatement of these objectives. A systematic program of research and development to provide operational solutions to the issues noted previously must be undertaken in order to assure cost-effective and efficient team performance for Air Force teams at all operational levels.

A reasonable first step toward such a research and development program should address the determination of how team training is currently conducted. A thorough assessment of the current status of team training should also identify issues which can be addressed through the application of existing or easily modifiable technology. A further potential benefit to be derived from a current status statement is the identification of team training issues of high potential payoff which will require further research. The development, refinement, and evaluation of optimal team training technology within the military environment would represent a significant step toward ensuring that Air Force systems will be operated and maintained so as to meet peacetime readiness and wartime deployment objectives.

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Laughlin, P.R., & Johnson, H.H. Group and individual performance on a complementary task as a function of initial ability level. *Journal of Experimental Social Psychology,* 1966, 2, 407-414.

Loftus, G.R., Dark, V.J., & Williams, D. Short-term memory factors in ground controller/pilot communication. *Human Factors,* 1979, 21(2), 169-181.

McRae, A.V. *Interaction content and team effectiveness.* HumRRO-TR-66-10, AD-637 311. Fort Benning, GA: The George Washington University Human Resources Research Office, 1966.

Meister, D. Team functions. In *Behavioral Foundations of System Development.* New York: John Wiley & Sons, Inc., 1976.

Morgan, B.B., Jr., Coates, G.D., Alluisi, E.A., & Kirby, R.H. *Training and performance effects of team training loads.* ITR-78-14. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, 1978.

Morrissette, J.O., Hornseth, J.P., & Shellar, K. Team organization and monitoring performance. *Human Factors,* 1975, 17(3), 296-300.

Naylor, J.C., & Briggs, G.E. Team training effectiveness under various conditions. *Journal of Applied Psychology,* 1965, 49, 223-229.

Nebeker, D.M., Dockstader, S.L., & Vickers, R.R., Jr. *A comparison of the effects of individual and team performance feedback upon subsequent performance.* NPRDC-TR-75-35. San Diego, CA: Navy Personnel Research and Development Center, 1975.

Nieva, V.F., Fleishman, E.A., & Rieck, A. *Team dimensions: Their identity, their measurement and their relationships.* Response Analysis Corporation. DAHC19-78-C-0001, Washington, D.C.: 1978.

Short, J.G., Cotton, T., & Klaus, D.J. *Increasing team proficiency through training: 7. The simulation of team environments.* AIR-E1-5/68-TR, AD-669 087. Pittsburgh, PA: American Institutes for Research Team Training Laboratory, 1968.

Swezey, R.W. An application of a multi-attribute utilities model to training analysis. *Human Factors,* 1979, 21(2), 183-189.

Thurmond, P., & Kribs, H.D. *Computerized collective training for teams: Final Report.* TR-78-A1, Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, 1978.

Vreuls, D., & Wooldridge, L. *Aircrew performance measurement.* Westlake Village, CA: Canyon Research Group, Inc., 1977.

Waag, W.L., & Halcomb, C.G. Team size and decision rule in the performance of simulated monitoring teams. *Human Factors,* 1972, 14(4), 309-314.

Wagner, H., Hibbits, N., Rosenblatt, R.D., & Schulz, R. *Team training and evaluation strategies: State-of-the-art.* HumRRO-TR-77-1. Alexandria, VA: Human Resources Research Organization, 1977.

Wallis, K.B., Ewart, W.L., & Kaufman, R.A. Instructional system approach to flight crew training. *Human Factors*, 1966, 8(2), 173-178.

Yaeger, B.W., & Bell, J.D. Techniques of quantitative performance measurement for ASW team trainers. Honeywell Marine Systems Division, California Center. In *Proceedings of the 10th NTEC/Industry Conference*, 1977.

TEAM TRAINING (T²) ANNOTATED BIBLIOGRAPHY

Alexander, L.T., & Cooperband, A.S. *System training and research in team behavior*. TM-2581. Santa Monica, CA: System Development Corporation, 1965.
Common training objectives were identified by examining computerized command-control systems. System training problems were discussed and a research program was outlined.

Alf, E.F., & Gordon, L.V. *A fleet validation of selection tests for underwater demolition team training*. TR 57-6, AD-144 092. U.S. Bureau of Naval Personnel, 1957.
The rela   nship between a battery of predictor tests for the underwater demolition team training program and Navy fleet performance was assessed. Correlational techniques were used on measures of both physical and cognitive capacities.

Alluisi, E.A. Lessons from a study of defense training technology. *Journal of Educational Technology Systems*, 1977, 5(1), 57-76.
The findings of a Defense Science Board Task Force on Training Technology were presented. The findings, as well as research implications and recommendations, were presented in the form of eight "lessons learned."

Baldwin, R.D., Frederickson, E.W., & Hackerson, E.C. *Aircraft recognition performance of crew chiefs with or without forward observers*. HumRRO-TR-70-12, AD-048 556. Alexandria, VA: Human Resources Research Organization, 1970.
The performances of single observers and four-member crews were compared using an aircraft recognition accuracy and decision speed task. Miniaturized simulations of aircraft which moved at scaled speeds, altitudes, and distances were evaluated and judged against test results from a full-scale test.

Bass, B.M. *Individual capability, team response and productivity*. Systems Research, Working Paper Series, State University of New York at Binghamton, 1977.
A framework was provided for studying the distribution of individual capabilities, role assignments, and organization in team performance. A model was presented which included a class of variables which contributed to team productivity. Implications for application and for research were included.

Beasley, J. Comparison of the performance of individu 's and three-member groups in a maze learning situation. *Journal of Perceptual and Motor Skills*, 1958, 8, 291-294.
Individual and group performances in a maze learning situation were compared. The dependent measures were number of trials and time to criterion.

Bennik. F.D., Hoyt, W.G., & Butler, A.K. *Determining TEC media alternatives for field artillery individual--collective training in the FY 78-83 period*. TR-78-A3, AD-A053 528. Santa Monica, CA: Systems Development Corporation, 1978.

Realism of situational training, active response, and sustained practice were emphasized in Army readiness. The report was designed to develop practical procedures, data s   s, and a resource management approach for use by training supervisor*

Biel, W.C., Harman, H.H., & Sheldon, M.S. *Exercising teams in military systems through the use of simulation*. SP-1739, AD-611 125. Santa Monica, CA: System Development Corporation, 1964.

The timeliness of training analyses and decisions was discussed. The design of team training programs and problems associated with evaluation were also explored.

Boguslaw, R., & Porter, E.H. Team functions and training. In R. M. Gagne (Ed.), *Psychological Principles in System Development*. New York: Holt, Rinehart and Winston, 1962, pp. 387-418.

This methodological development covered the topics of team functions and training, team training technologies, and designing system training with particular emphasis on the distinction between "established" and "emergent" team situations. The authors concluded by presenting a research prospective.

Briggs, G.E. *On the scheduling of training conditions for the acquisition and transfer of perceptual-motor skills*. NAVTRADEVCEN 836-1. U.S. Naval Training Device Center, 1961.

Task changes appropriate to teaching vehicular control were studied as a function of skill level increases with practice. A series of three experiments were reported in this study.

Briggs, G.E., & Johnston, W.A. *Team training research*. NAVTRADEVCEN TR-1327-2. Columbus, OH: The Ohio State University, Human Performance Center, 1965.

Team training in a Combat Information Center (CIC) environment was studied. Two-member teams were required to coordinate radar-controlled air intercepts. Training task fidelity was varied and the ability to coordinate was measured.

Briggs, G.E., & Johnston, W.A. Influence of a change in system criteria on team performance. *Journal of Applied Psychology*, 1966, 50(6), 467-472. (a)

The influence of transfer from one criterion condition to another on a radar control task was investigated. Whether the subject was transferring to a simpler or more complex task was also studied for a possible influence.

Briggs, G.E., & Johnston, W.A. *Laboratory research on team training*. NAVTRADEVCEN TR-1327-3, Columbus, OH: The Ohio State University, Human Performance Center, 1966. (b)

Two team training experiments which required two-member coordination were performed. Both the criteria used to feed back system performance information and the channel available for coordination information were varied and the effect on radar control aerial intercepts was studied.

Briggs, G.E., & Johnston, W.A. Stimulus and response fidelity in team training. *Journal of Applied Psychology*, 1966, 50, 114-117. (c)

High and low stimulus fidelity and high and low response fidelity were varied between training and transfer test situations. The task was radar control and two-member teams were used. The results suggested procedures for maximizing transfer of training.

Briggs, G.E., & Johnston, W.A. *Team training.* NAVTRADEVCEN-1327-4, AD-660 019. Columbus, OH: The Ohio State University, Human Performance Center, 1967.
A 4-year laboratory research program on team training was reported. Conclusions were drawn with respect to team performance as it related to task, training, and communications variables. The uses of certain team training devices were also addressed. A literature review was included.

Briggs, G.E., & Naylor, J.C. *Experiments on team training in a CIC-type task environment.* NAVTRADEVCEN-TR-1327-1, AD-608 309. Columbus, OH: The Ohio State University, Laboratory of Aviation Psychology, 1964.
Three-member teams were used in a simulated radar-control interception task. Three experiments were reported. Experiment one tested for the influence of replacing one team member with a new operator with varying experience. Experiment two varied training task fidelity and organization and transfer task organization. Experiment three varied operator experience.

Briggs, G.E., & Naylor, J.C. Team versus individual training, training task fidelity and task organization effects on transfer performance by three-man teams. *Journal of Applied Psychology,* 1965, 49, 387-392.
This study was an extension of an earlier effort by the authors which investigated the effect of task organization on team performance. The present study extended the task organization variable and included an investigation of training task fidelity as a possible variable.

Brown, E.L., Stone, G., & Pearce, W.E. *Improving cockpits through flight crew workload measurement.* Paper presented at the Second Advanced Aircrew Display Symposium, Naval Air Test Center, Patuxent River, MD, 1975.
A computerized technique with emphasis on design factors was described for selecting between alternate crew station layouts, controls, and displays. A sequence or time frame approach was used to allow more consideration for high workload items.

Chapman, R.L., Kennedy, J.L., Newell, A., & Biel, W.C. *The Systems Research Laboratory's air defence experiments.* Paper presented at the American Psychological Association meeting in San Francisco in September, 1955.
The incidents, impressions, and data of RAND's Systems Research Laboratory air defence experiments between 1952 and 1954 were presented. Training principles derived from the experiments were the basis of a training program implemented by the System Development Corporation.

Cockrell, J.T. *Maintaining image interpreter proficiency through team consensus feedback.* BESRL-TR-Note-195. Washington, D.C.: Behavioral Science Research Laboratory, 1968.
An exploratory study was reported in which "team consensus feedback" led to improvement in individual interpreter performance. This technique was also considered valuable in maintaining interpreter proficiency in field situations using operational imagery and where an on-the-job training requirement exists.

Cockrell, J.T., & Sadacca, R. *Training individual image interpreters using team consensus feedback.* TRP-1171. System Development Corporation, 1971.
The usefulness of the "consensus feedback" process in target detection and identification was assessed. "Team consensus feedback" was defined as the use of consensual judgment of interpretation team members in reducing target identification errors made by individuals when working alone. Four experiments were reported.

Collins, J.J. *A study of potential contributions of small group behavior research to team training technology development.* NR-170-834, Arlington, VA: Organizational Effectiveness Research Programs, Office of Naval Research, 1977.
Theories, methods, techniques, and findings related to the variables in group interaction, performance, productivity, growth, and development were reviewed from the literature on small group behavior research. Research program recommendations and an annotated bibliography were included.

Crawford, M.P. *A review of recent research and development on military leadership, command, and team function.* The George Washington University Human Resources Research Office, Alexandria, VA. Paper presented at the Annual Convention of the American Psychological Association, 1964. (AD 478 288).
Recent research and development on military leadership, command, and team functioning was reviewed.

Crawford, M.P. *Research in military training.* HUMRRO-PP-19-74, AD-105 104. Alexandria, VA: Human Resources Research Organization, 1974.
HumRRO studies were reported in the areas of improving individual performance, unit training and performance, leadership training, command and control, training technology, and training management.

Cream, B.W., & Lambertson, D.C. *Functional integrated systems trainer: Technical design and operation.* AFHRL-TR-75-6, AD-A015 835. Wright-Patterson AFB, OH: Advanced Systems Division, Air Force Human Resources Laboratory, June 1975.
The training value of a USAF crew training device was evaluated. This functional part-task trainer was designed with a reliance on behavioral task analysis data. The device was found to provide effective individual and crew coordination training.

Dahlgren, H.K. *Crew training. A comprehensive program.* WSG-TA-75-13. Anchorage, AL: Paper presented at the Symposium on Science and Natural Resources in the Gulf of Alaska, 1975.
The importance of crew training for vessel operation was discussed. Thirteen steps were outlined as important considerations for the organization of a full scale training program.

Daniels, R.W., Alden, D.G., Kanarick, A.F., Gray, T.H., & Feuge, R.L. *Automated operator instruction in team tactics.* NAVTRADEVCEN-70-C-0310-1, AD-736 970. St. Paul, MN: Honeywell, Inc., 1972.
The authors investigated the question of whether there is sufficient commonality in Navy tactical team tasks to warrant development of a team training system which takes advantage of specific available advanced technologies.

Defense Science Board. *Crew/group/team/unit training.* In Defense Science Board, Report of the Task Force on Training Technology. Office of the Director of Defense Research and Engineering, Washington, D.C., 1976.
Crew/Group/Team/Unit (CGTU) training was discussed within a military context. The scope, description, costs, research and development (R&D) support, application and implementation, management concerns, and recommendations of CGTU training were addressed in this chapter.

Eckstrand, C.A. *Current status of the technology of training.* AMRL-TR-64-86, AD-608 216. Wright-Patterson AFB, OH: Aerospace Medical Research Laboratories, 1964.
  A summarization and evaluation of training technology was presented in this overview. Training system design processes were analyzed into: (1) determining training requirements, (2) developing the training environment, and (3) measuring the results of training. Future research and development needs were discussed.

Egerman, K., Glaser, R., & Klaus, D.J. *Increasing team proficiency through training. 4. A learning theoretic analysis of the effects of team arrangement on team performance.* AIR-B64-9/63-TR, Pittsburgh, PA: American Institutes for Research, Team Training Laboratory, 1963.
  The interrelationship of the performances of team members was studied to assess its effect on the influence of team feedback. Two-member teams were constructed both in parallel and in series arrangements. The results were interpreted in terms of a "learning-theoretic" view of team performance.

Egerman, K., Klaus, D.J., & Glaser, R. *Increasing team proficiency through training. 3. Decremental effects of reinforcement in teams with redundant members.* AIR-B64-6/62-TR, Pittsburgh, PA: American Institutes for Research, Team Training Laboratory, 1962.
  The effects of feedback applied to team output were investigated. This effort studied "redundant" teams ;which have members arranged in parallel, such that reinforcement is a function of the performance of either one or more of its parallel members.

Eggemeier, F.T., & Cream, B.W. *Some considerations in development of team training devices.* Paper presented at the 1978 American Psychological Association Meeting, Toronto, Ontario, Canada. A task analytic technique was described that had proven useful in the design of a fire control team training device for the AC-130E Gunship. The technique was based upon careful task analyses and represented an extension of conventional ISD techniques. Models of team behavior were presented.

Faust, G.W. *Team training and ISD.* Orem, UT: Courseware, Inc., 1976.
  Effective team training was viewed as an integrated part of an overall training program. Instructional Systems Development (ISD) was suggested as a general framework within which to identify, design, and validate team training components. Techniques for ensuring team training considerations within a training program were advanced.

Federman, P., & Siegel, A.I. *Communications as a measurable index of team behavior.* NAVTRADEVCEN-1537-1. Wayne, PA: Applied Psychological Services, Science Center, 1965.
  "The relationship between anti-submarine warfare (ASW) helicopter team performance and the content and flow of communications within the team during a simulated attack was investigated." Fourteen different communications variables were determined to be correlated with the performance criterion.

Foot, H.C. Group learning and performance: A reclassification. *British Journal of Social and Clinical Psychology,* 1973, 12, 7-17.
  A distinction between "coaction" and "interaction" was redefined and a classification system was based upon that re-examination. Classifications of group learning and performance tasks were presented.

Glanzer, M. Experimental study of team training and team functioning. In R. Glaser (Ed.), *Training Research and Education.* University of Pittsburgh, Department of Psychology, Pittsburgh, PA, 1961, pp. 437-468.
  An analysis of problems in team training that can be examined experimentally was presented. Reports of how teams react in the field and some special aspects of laboratory teams were reviewed.

Glanzer, M., & Glaser, R. *A review of team training problems.* American Institutes for Research, Pittsburgh, PA, 1955.
A general overview of Navy team training was presented. The team was presented as a communication network. Characteristics of effective and ineffective teams, errors in training and their causes, interchangeability of personnel, and cross-training were discussed. Some techniques for the study and improvement of team training were suggested.

Glanzer, M., Glaser, R., & Klaus, D.J. *The team performance record: An aid for team analysis and team training.* Office of Naval Research, Psychological Sciences Division, 1956. (AD-123 615).
Observations of Navy team operations were made to determine the factors that contribute to effective team performance. A procedure ("The Performance Record") was established as a tool for the observation, evaluation, and improvement of Navy team behavior.

Glaser, R., & Glanzer, M. Dimensions of team performance and team training problems. In, *Symposium on Electronics Maintenance,* Advisory Panel on Personnel and Training Research, Office of the Assistant Secretary of Defense, Research and Development, 1955.
A discussion of team training and procedures for improving team performance were offered. Four primary topics were covered: team description, team training, evaluation and measurement of team performance, and team construction.

Glaser, R., & Klaus, D.J. *A reinforcement analysis of group performance.* American Institutes for Research Team Training Laboratory, Pittsburgh, PA, 1965. (AD-640 624).
Three-member "series" and "parallel" teams were used to investigate response feedback and reinforcement contingencies occurring in a team environment. Processes studied included response acquisition, extinction, spontaneous recovery, reacquisition, and reextinction. Feedback was based on either group or individual performance.

Glaser, R., & Klaus, D.J. *Studies of the reinforcement components of group performance.* Office of Naval Research, 1967.
A learning theory approach to group performance was described which emphasized reinforcement contingencies as a central variable in small group performance. The distinction between serial and parallel group compositions and the effect of a redundant member were considered.

Glaser, R., Klaus, D.J., & Egerman, K. *Increasing team proficiency through training. 2. The acquisition and extinction of a team response.* AIR-B64-5/62-TR. Pittsburgh, PA: American Institutes for Research, Team Training Laboratory, 1962.
Team learning was studied varying many of the same factors as those which have been shown to affect individual learning. The primary factors investigated were the feedback contingencies that followed the overall team response. An operant conditioning model was employed.

Haines, D.B. *Training for group interdependence.* AMRL-TR-65-117, Wright-Patterson AFB, OH: Aerospace Medical Research Laboratory, 1965.
The effect of group interdependency within USAF training programs was investigated. Group interactions were investigated for their effects on overall performance in military situations. Cooperation was contrasted with a competitive orientation.

Hall, E.R. *Some current issues in tactical team training.* Navy Training Analysis and Evaluation Group, Orlando, FL, 1976.
Contributions to understanding the nature of team functioning and defining training program needs were made. Key issues were discussed and recommendations for improving tactical team training were offered.

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Hall, E.R., & Rizzo, W.A. *An assessment of U.S. Navy tactical team training: Final report.* TAEG Report No. 18. Orlando, FL: Training Analysis and Evaluation Group, 1975.
  The technical literature was reviewed to collect information for planning Navy tactical team training. Current practices were discussed in relation to the findings of the literature review and recommendations were presented.

Hammell, T.J., & Mara, T.D. *Application of decision making and team training research to operational training: A translative technique.* NAVTRADEVCEN 68-C-0242-1, AD-871 984. General Dynamics Corporation, 1970.
  A thorough presentation of the procedure used to develop a decision making device for operational training was made. The results of laboratory decision making research were presented and applications to operational training systems were demonstrated.

Hogan, J.C. *Trainability of abilities: A review of nonspecific transfer issues relevant to ability training.* ARRO-3010-TR1. Washington, D.C.: Advanced Research Resources Organization, 1978.
  The effects of training on related but nonidentical tasks were assessed in an attempt to determine whether ability training is feasible. Plans for transfer mediation and implications were discussed.

Hood, P.D., Krumm, R.L., O'Sullivan, F.J., Buckhout, R., Cave, R.Y., Cotterman, T.E., & Rockway, M.R. *Conference on integrated aircrew training.* WADD-TR-60-320, Wright-Patterson AFB, OH, 1960.
  Portions of this report stressed the need for training in crew coordination in addition to individual competencies. Measures of crew coordination were also described. Included, also, was a description of the first "integrated crew trainer."

Horrocks, J.E., Heermann, E., & Krug, R.E. *Team training III: An approach to optimum methods and procedures.* NAVTRADEVCEN 198-5, Columbus, OH: Ohio State University, 1961.
  Laboratory results using three-member teams in structured task-oriented settings were reported. The acquisition phases of learning were of particular interest. The relative importance of team coordination vs. individual performance in skill acquisition was discussed.

Horrocks, J.E., Krug, R.E., & Heermann, E. *Team training II: Individual learning and team performance.* NAVTRADEVCEN 198-2. Columbus, OH: The Ohio State University Research Foundation, 1960.
  The effectiveness of team performance under various training conditions and different feedback conditions was evaluated. There were two tasks involved: a sentence decoding task, and a position judgment task. Implications for applied procedures were drawn.

Hulten, B.H. *Games and teams: An effective combination in the classroom.* Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL, 1974 AD-090 927.
  The relative contributions of team competition and peer group practice to classroom instructional effectiveness were investigated. Reward system (team competition vs. individual competition) and practice (group practice vs. individual practice) were combined in a 2x2 factorial design. The dependent variable was performance on a modified version of the math game "Tuf."

Jeantheau, G.G. The use of multi-man system trainers. *Ergonomics*, 1969, 12(4), 533-542.
  A guide for the use of an antisubmarine warfare trainer was described. Four principles for effective tactical team training were presented.

Johnson, H.H., & Torcivia, J.M. Group and individual performance on a single-stage task as a function of distribution of individual performance. *Journal of Experimental Social Psychology*, 1967, 3(3), 266-273.

This research investigated group and individual performance on a single-stage mathematical puzzle. The distribution of individual performance in relation to group performance confirmed the authors' hypothesis that group performance is simply a combination of members' resources.

Johnston, W.A. Transfer of team skills as a function of type of training. *Journal of Applied Psychology*, 1966, 50, 102-108.

Team and individual trainings were contrasted for tasks that required extensive teamwork. A simulated radar controlled air intercept task was used. The degree of coordination and number of "hits" scored were the dependent measures.

Johnston, W.A. Individual performance and self-evaluation in a simulated team. *Organizational Behavior and Human Performance*, 1967, 2, 309-328.

How well team members perceived that they performed and how well they actually performed were investigated as a function of actual team output. The task was a simulated tracking manipulation and integrated absolute error was recorded. Changes in criteria and self-evaluations were used.

Johnston, W.A., & Briggs, G.E. Team performance as a function of team arrangement and workload. *Journal of Applied Psychology*, 1968, 52(2), 89-94.

Two team functions ("fail-stop" and "compensatory"), intermember communication, and workload were investigated to determine their effects on team output. The fail-stop function was one in which team members prevented their partner from making a mistake. With the compensatory function, a partner corrected a mistake after it had been committed.

Kanarick, A.F., Alden, D.G., & Daniels, R.W. Decision making and team training in complex tactical training systems of the future. In *Naval Training Device Center 25th Anniversary Commemorative Technical Journal*, 1971, 67-77.

The implications of trends in Navy tactical training were discussed in terms of the training of individuals and teams in tactical and decision making skills. Two approaches to decision-making training were assessed and principles of effective team training were related to decision making. The requirements imposed by new tactical systems were also discussed.

Kennedy, J.L. The system approach: Organizational development. *Human Factors*, 1962, 4(1), 25-52.

How people behave in groups was investigated within a "synthetic organism" context. The organization was viewed as a different entity within which individuals became parts or sub-parts of that entity. The treatment, development, and growth of these "synthetic environments" was discussed.

Killian, L. *Minimize or maximize? Education and training for tomorrow's technical Navy.* Paper presented at the Annual Meeting of the Association of Educational Communications and Technology, Miami Beach, FL, 1977. (ED-142 196).

A Group Assisted Self-Paced (GRASP) program of individualized instruction in groups of 16 was described. The GRASP program was presented as retraining self-paced, individualized instruction while building group identity and instructor leadership.

Kinkade, R.G., & Kidd, J.S. *The effect of team size and intermember communication on decision-making performance.* WADC-TR-58-474. Wright-Patterson AFB, OH, 1959.

A complex decision making "game" derived from radar approach control was used to measure the performance of individuals and two-member teams with, and without intercommunication. The dependent measure was productivity per person. An examination of individual performance vs. individual in a group performance was made.

Klaus, D.J., & Glaser, R. *Studies of Navy guided missile teams: Final report.* Pittsburgh, PA: American Institutes for Research, 1958.

This brief summary of research project activities conducted by the American Institutes for Research under contract with the Office of Naval Research included a digest of activities, a brief history, and an annotated bibliography of reports produced by the project staff. No technical findings were reviewed.

Klaus, D.J., & Glaser, R. *Increasing team proficiency through training, I. A program of research.* AIR-264-60-TR-137, AD-252 866. American Institutes for Research, 1960.

A program of research was described which attempted to explore various fundamental aspects of team proficiency. Of primary interest was the process by which the proficiency of a team, as a whole, develops. A learning theory model was used.

Klaus, D.J., & Glaser, R. *Team learning as a function of member learning characteristics.* American Institutes for Research, Pittsburgh, PA, 1963.

Team proficiency was manipulated using operant conditioning techniques. The extent to which the individual learning characteristics of team members affect the acquisition and extinction of team responses was studied.

Klaus, D.J., & Glaser, R. *Increasing team proficiency through training. 5. Team learning as a function of member learning characteristics and practice conditions.* AIR-E1-4/65-TR, Pittsburgh, PA: American Institutes for Research, Team Training Laboratory, 1965.

The variables investigated in this study of team learning included individual response proficiency, rate of proficiency attainment, homogeneity of proficiency among team members, and delay between individual and team learning. Three-member teams were studied.

Klaus, D.J., & Glaser, R. *Increasing team proficiency through training. 8. Final summary report.* AIR-E1-6/68-FR, Pittsburgh, PA: American Institutes for Research, 1968.

This report summarized seven technical reports on team training covering a time period from December 1960 through August 1967. Each of the seven research studies was described and reviewed. This report concluded by identifying practical implications and underlying concepts of the research efforts.

Klaus, D.J., & Glaser, R. Reinforcement determinants of team proficiency. *Organizational Behavior and Human Performance,* 1970, 5(1), 33-67.

Both "series" teams (requiring specific input from each member) and "parallel" teams (containing redundant members) were used to assess the differential effects of group reinforcement on individual team members. The effects of entering performance, supplementary feedback and simulation on training were studied.

Klaus, D.J., Grant, L.D., & Glaser, R. *Increasing team proficiency through training. 6. Supervisory furnished reinforcement in team training.* AIR-E1-5/65-TR, Pittsburgh, PA: American Institutes for Research, Team Training Laboratory, 1965.

The effect of simulated supervisory reinforcement on the speed of team response acquisition was studied. This report offered an explanation for a previously noted reduction in individual team member proficiencies when individual training was terminated and team training was begun.

Kribs, H.D., Thurmond, P., & Mark, L. *Computerized collective training for teams.* ARI-TR-77-A4. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, 1977.

A review and evaluation of the available literature applicable to the development of instructional strategies for computer-assisted team training was conducted. The major elements required for the derivation of team training instructional strategies were also identified.

Krumm, R.L. *The effectiveness of integrated crew simulator training in developing crew coordination skills.* AIR-238-S9-IR-96, Washington, D.C.: American Institutes for Research, 1959.
A 30-month study designed to assess the value of a linkage device for promoting crew coordination was summarized. A presentation of techniques employed and results obtained was included.

Krumm, R.L., & Farina, A.J., Jr. *Evaluation of a B-52 integrated flight simulator for its crew coordination training potential as measured by crew communications and performance measures.* AIR-327-61-FR-239, Washington, D.C.: American Institutes for Research, 1961.
The results of a study to assess the value of electronically linking crew training simulators to allow for more realistic crew coordination practice were discussed. New devices were also investigated in an attempt to determine more precisely the nature of crew coordination activities.

Krumm, R.L., & Furina, A.J., Jr. *Effectiveness of integrated flight simulator training in promoting B-52 crew coordination.* AMRL-TDR-62-1, Pittsburgh, PA: American Institutes for Research, 1962.
The value of a B-52 flight simulator coupled to a navigator trainer for promoting crew coordination was assessed. Special attention was given to two aspects of communication (pattern and volume) and their relationships to crew coordination.

Kurlloff, A.H., & Yoder, D. *Teamwork in task analysis. Training manual V. Evaluation of the Marine Corps task analysis program.* TR-9, ED 127 421. Arlington, VA: Office of Naval Research, Personnel and Training Research Programs Office, 1975.
This training manual provided guidelines for effective teamwork and team development. The major obstacles to optimal team performance were discussed and "management by objectives" in teamwork was explained. An annotated bibliography was included.

Laughlin, P.R., & Johnson, H.H. Group and individual performance on a complementary task as a function of initial ability level. *Journal of Experimental Social Psychology,* 1966, 2, 407-414.
The effects of group as opposed to individual performance on a "complementary task" was studied as a function of initial ability level. A complementary task was defined as one in which each person is assumed to possess some resources that are unshared by the other group members. Subjects worked in pairs.

Lemke, E.A., & Hecht, J.T. Effects of degree of training, group size, and inductive ability on the transfer of conceptual behavior. *The Journal of Educational Research,* 1971, 65, 43-45.
This experiment served as a partial replication of studies which have indicated that training low-ability subjects in homogeneous pairs facilitates individual transfer performance on concept attainment tasks.

Levy, B.I. *A preliminary study of informal crew conferences as a crew training adjunct.* AFPTRC-TR-54-87, AD-066 043. Lackland AFB, TX: Air Research and Development Command, Air Force Personnel and Training Research Center, 1954.
The effect of crew conferences as an aid to aircraft crew technical training was investigated. The conferences allowed for informal and interpersonal crew member interactions. Attitude measures, a sociometric test, and a measure of psychological tension were the dependent measures.

Loftus, G.R., Dark, V.J., & Williams, D. Short-term memory factors in ground controller/pilot communication. *Human Factors,* 1979, 21(2), 169-181.
Sources of memory errors in an air traffic control system were investigated using simulation techniques. Two major determinants of error probability were identified. Implications for improvement within the information encoding scheme were made.

McFann, H.H. *Training for the military*. HumRRO-PP-3-76. Alexandria, VA: Human Resources Research Organization, 1976.

> Data and trends concerned with military training were summarized as they apply primarily to individual training. Basic training and specialized skill training were discussed. Complexities and cost considerations were observed.

McRae, A.V. *Interaction content and team effectiveness*. HumRRO-TR-66-10, AD-637 311. Fort Benning, GA: The George Washington University, Human Resources Research Office, 1966.

> The effectiveness of small combat teams which require cooperation and coordination among individual members was investigated. The primary goal was to study the relationship between the interaction of a working team and its effectiveness.

Meister, D. Team functions. In *Behavioral Foundations of System Development*. New York: John Wiley & Sons, Inc., 1976.

> This chapter investigated the effects of team variables and training on team performance improvement. Among the variables discussed were team size, composition, organization, training, performance, communication, attitudes, and motivation. Developmental implications were included.

Morgan, B.B., Jr., Coates, G.D., Alluisi, E.A., & Kirby, R.H. *Training and performance effects of team training loads*. ITR-78-14. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, 1978.

> The data of 10 studies were combined and reported in this interim technical report. The studies investigated the effects of different percentages of untrained team personnel on training and performance effectiveness. Implications for optimizing team training strategies and performance effectiveness were discussed.

Morrissette, J.O., Hornseth, J.P., & Shellar, K. Team organization and monitoring performance. *Human Factors*, 1975, 17(3), 296-300.

> Varying labor differentiation conditions were used to study individual and two-member team performance. The task was signal detection of multiple displays. Implications for team organization (for detection tasks) were derived.

Nagay, J.A. *Research related to CGTU training*. Paper presented at the 1978 Meeting of the Training and Personnel Technology Conference (TPTC) on Crew, Group, Team, and Unit (CGTU) Training, Washington, D.C.

> U.S. Navy Research concerned with team training in an information processing or problem solving context was presented. Human interaction variables were related to Crew, Group, Team, and Unit (CGTU) training research.

Naylor, J.C., & Briggs, G.E. Team-training effectiveness under various conditions. *Journal of Applied Psychology*, 1965, 49, 223-229.

> Dynamic team functioning was examined by adding substitute members with varying experience levels and by altering task complexity and organization. The task involved simulated radar control of manned interceptors.

Naylor, J.C., & Dickinson, T.L. Task structure, work structure, and team performance. *Journal of Applied Psychology*, 1969, 53(3), 167-177.

> Two levels of task structure, two levels of task organization, three levels of work structure, and five l locks of 40 trials each were factorily combined with team achievement as the dependent measure. This study was essentially a test of the Dickinson-Naylor taxonomy of team performance (1969).

Nebeker, D.M., Dockstader, S.L., & Vickers, R.R., Jr. *A comparison of the effects of individual and team performance feedback upon subsequent performance.* NPRDC-TR-75-35. San Diego, CA: Navy Personnel Research and Development Center, 1975.
The effect of performance feedback presented to individuals who are or are not members of a team was assessed. Variation as a result of team membership or the amount and specificity of feedback was studied.

Nelson, P.D., & Berry, N.H. *Cohesion in Marine recruit platoons.* NAVMED-MFO-22.01.04-9001, AD-667 615. San Diego, CA: Navy Medical Neuropsychiatric Research Unit, 1968.
The relationship of cohesiveness to personnel composition, attitudes, and performance was studied in Marine basic training platoons. The stability of cohesiveness over a 2-month period was also observed.

Nieva, V.F., Fleishman, E.A., & Rieck, A. *Team dimensions: Their identity, their measurement and their relationships.* DAHC 19-78-C-001, Washington, D.C.: Response Analysis Corporation, 1978.
Basic questions about the nature of team performance and the factors affecting it were investigated. An extensive literature review and propositions which emerged from the review were included. A new conceptualization of team performance was developed.

Obermayer, R.W., Vreuls, D., Muckler, F.A., & Conway, E.J. *Combat-ready crew performance measurement system: Phase IIID. Specifications and implementation plan.* AFHRL-TR-74-108 (VII), AD-B005 522L. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, December 1974. (a)
Specifications and an implementation plan were presented for a performance measurement system which was divided into three major subsystems: Data acquisition, data processing, and personnel. The implementation plan detailed five major steps.

Obermayer, R.W., & Vreuls, D. *Combat-ready crew performance measurement system: Phase I. Measurement requirements.* AFHRL-TR-74-108 (II), AD-B005 518. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, December 1974.
Training sites were visited and experts were interviewed as input to a proposed measurement system which would serve as a useful tool for research on combat-crew training problems. This study also provided a useful foundation for performance measurement studies.

Obermayer, R.W., & Vreuls, D. *Combat-ready crew performance measurement system: Phase II. Measurement system requirements.* AFHRL-TR-74-108 (III), AD-B005 519. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, December 1974. (b)
This study reported findings of phase two of a three-phase effort into "Research on Operational Combat-Ready Proficiency Measurement" performed by Manned Systems Sciences, Inc. This phase of the effort concentrated on the requirements for a measurement system including research procedures, measurement processing, system criteria, and preliminary system analyses.

Obermayer, R.W., & Vreuls, D. *Combat-ready crew performance measurement system: Phase IIIA, crew performance measurement.* AFHRL-TR-74-108(IV), AD-B005 520. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, December 1974.
The systems approach to the design of a measurement system was used to gather information applicable to combat-crew training. The program was designed to phase through six major activities: (1) requirement definition, (2) conceptual design, (3) modification of definition and conceptual design stages, (4) design of studies, (5) specification determination, and (6) report.

Obermayer, R.W., Vreuls, D., & Conway, E.J. *Combat-ready crew performance measurement system. Phase IIIC. Design studies.* AFHRL-TR-74-108(VI), AD-B005 521L. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, December 1974.
This phase looked at design studies to identify desirable system features associated with training measurement system design. The nature of criterion tradeoffs was discussed and recommendations were offered.

Obermayer, R.W., Vreuls, D., Muckler, F.A., Conway, E.J., & Fitzgerald, J.A. *Combat-ready crew performance measurement system: Final report.* AFHRL-TR-74-108(I), AD-B005 517L. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, December 1974.
This report described a combat-ready crew performance system project with two primary objectives. The first was to define appropriate performance measures. The second was to define a cost-effective measurement system. Implications for the development of such a system were discussed.

Parlour, R.R. Executive team training. *Academy of Management Journal,* 1971, 14, 341-344.
A discussion of executive team training as the key to successful management was presented. The psychological issues rather than the process were addressed. Executive team training was presented as an ongoing process.

Parsons, H.M. *What the Navy's anti-air warfare training program can learn from air defense system training experience.* NR 170-032. Washington, D.C.: Office of Naval Research, 1964.
Lessons gleaned from experiences with air defense system training were derived from operational exercises, simulated environments, instructional techniques, and the combination of operational training exercises and simulation as both a training program and a method of measuring and evaluating performance.

Payne, W.H., & Braunstein, D.N. *Suitability of a simple task for the study of team training problems.* SRM-65-5. San Diego, CA: Chief of Naval Personnel, 1965.
The effects of three team organizing conditions on signal detection performance were assessed. The organizing conditions included individual, sequential. and parallel arrangements. The task was to distinguish a visual signal from background noise.

Prophet, W.W., & Caro, P.W. *Simulation and aircrew training and performance.* HumRRO-PP-4-74. Alexandria, VA: The George Washington University Human Resources Research Office, 1974.
Major areas of U.S. Army simulation usages were outlined. Equipment development, crew performance, and training were emphasized. A program which emphasizes engineering and behavior principles was suggested.

Ratliff, F.R., Chiorini, J.R., Curran, C.R., & Shore, C.W. *Evaluating combat crew training performance using criteria of minimum performance standards.* AFHRL-TR-70-50, AD-722 409.
Lackland AFB, TX: Personnel Division Air Force Human Resources Laboratory, November 1970. An 11-point rating scale and minimum acceptable performance criteria were developed to measure training progress for the F-4 combat crew. The effects of previous crew member experiences on performance in combat crew training school were assessed.

Savage, R.E. *A multiple-regression information-processing approach for assigning individuals to a training strategy.* Masters thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA, 1979.
A method for maximizing training efficiency within the constraints of time, money and the skills needed was developed. The approach involved matching a particular training strategy to individual characteristics.

Shriver, E.L., Mathers, B.L., Griffin, G.R., Word, L.E., & Root, R.T. *REALTRAIN: A new method for tactical training of small units.* Kinton, Inc., Alexandria, VA, 1975. (AD-A024 030/9ST).
A low-cost tactical training and evaluation technique for use in Army unit combat training was described. Simulated combat situations which are realistic, two-sided and interactive were employed. The system was based on standard learning theory principles.

Siegal, A.I., & Federman, P.J. Communications content training as an ingredient in effective team performance. *Ergonomics*, 1973, 16(4), 403-416.
The relationship between helicopter team performance and the type and amount of communication among the team members was investigated. Information derived from this study would be used to develop a course which used communications content as a basis for improving on-the-job effectiveness.

Siskel, M., Jr., Lane, F.D., Powe, W.E., & Flexman, R.E. *Intra-crew communication of B-52 and KC-135 student and combat crews during selected mission segments.* AMRL-TR-65-18, AD-617 598. Wright-Patterson AFB: OH, May 1965.
Within-crew communications during peacetime training flights were examined as a function of crew experience and selected mission tasks. Crew transmission and message rates were the dependent measures.

Short, J.G., Cotton, T., & Klaus, D.J. *Increasing team proficiency through training: 7. The simulation of team environments.* AIR-E1-5/68-TR, AD-669 687. Pittsburgh, PA: American Institutes for Research Team Training Laboratory, 1968.
Three studies of simulated team environments were used to study the decrement in individual performance which occurs when individuals are transitioned to teams. A learning theory approach was followed.

Smith, E.A. *Four systems for controlling multiscreen or team training presentations.* AFHRL-TR-77-83, AD-A055 093. Lowry AFB, CO: Technical Training Division, Air Force Human Resources Laboratory, December 1977.
Procedures and techniques were developed for generating simultaneous presentations of more than one visual image or images with more than one visual component. The techniques were applicable to coordinated or team training instructional situations. The discussion included implementation instructions. Results of a field test and a usability evaluation were also included.

Smode, A.F. Recent developments in training problems, and training and training research methodology. In R. Glaser (Ed.) *Training Research and Education.* University of Pittsburgh, Department of Psychology, Pittsburgh, PA, 1961, pp. 493-573.
A compilation of training methods, materials and procedures of training and training research was presented. The chapter was designed to provide researchers with ideas, techniques and procedures. Research implications were included.

Sweezy, R.W. An application of a multi-attribute utilities model to training analysis. *Human Factors*, 1979, 21(2), 183-189.
A Bayesian-oriented decision making paradigm was applied to a military training analysis problem. Results of the "multiattribute utilities model" application were discussed and a comparison was made with a simple judgment analysis model.

Thurmond, P., & Kribs, H.D. *Computerized collective training for teams: Final report.* ARI-TR-78-A1. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, 1978.
A demonstration and evaluation of a brassboard for Computerized Collective Training for Teams (COLT^2) was conducted. The design and implementation of a team Instructional Systems Development (ISD) model from which sample training materials developed was included.

Trussell, J.H., Watts, G.W., Potter, N.R., & Dieterly, D.L. *Team performance research: A review.* Dayton, OH: Systems Research Laboratories, Inc., 1977.
A literature search was conducted into team member interaction and the individual capability of group members. Team functioning under conditions of stress or task overload was given particular emphasis. Research program recommendations were suggested.

TRW Systems Group. *Spacelab cost reduction alternatives study. Volume 3: Crew training task analysis.* TRW-26904-6002-TU-00-V-3. Redondo Beach, CA: TRW Systems Group, 1975.
Functions necessary to meet flight objectives were identified. Each function was then analyzed to determine the major activities which contributed to the function. Each major activity was further analyzed to define specific operator tasks. Training analysis worksheets were used to document the analysis of each function.

Vreuls, D., & Obermayer, R.W. *Study of crew performance measurement for high-performance aircraft weapon system training: Air-to-Air intercept.* NAVTRADEVCEN 70-C-0059-1, Northridge, CA: Manned Systems Sciences, Inc., 1971.
The development of methods and measurements for the requirements of an automated high-performance weapon system trainer was discussed. The problem included the specification of measurement for training of the pilot alone, the weapon system operator alone, and of both as a two-member team.

Vreuls, D., & Wooldridge, L. *Aircrew performance measurement.* Westlake Village, CA: Canyon Research Group, Inc., 1977.
One approach to the development of aircrew performance measurement was used to examine some of the considerations, methodological issues, and progress in selected areas of measurement analysis. The approach stressed the aircrew environment.

Wang, W.L., & Halcomb, C.G. Team size and decision rule in the performance of simulated monitoring teams. *Human Factors,* 1972, 14(4), 309-314.
The effects of team size and the decision rule used to define the requirements of a team response on team monitoring performance were investigated. Teams were composed of from two to five members and the decision rule reflected either a parallel or a series response condition.

Wagner, H., Hibbits, N., Rosenblatt, R.D., & Schulz, R. *Team training and evaluation strategies: State-of-the-art.* HumRRO-TR-77-1, Alexandria, VA: Human Resources Research Organization, 1977.
Information for planning research and development programs in the area of team training was provided in this literature review. Gaps in team training strategies and evaluation techniques as well as new team training strategies and evaluation techniques were identified.

Wagner, R.J. Rehabilitation team practice. *Rehabilitation Counseling Bulletin,* 1977, 20(3), 206-215.
The literature and experimental research on teamwork were reviewed. Implications for team practice were drawn and the difference between group interaction and pooled individual responses was discussed.

Wallis, K.B., Ewart, W.L., & Kaufman, R.A. Instructional system approach to flight crew training. *Human Factors,* 1966, 8(2), 173-178.
The rationale for analysis and definition of flight crew training requirements was discussed. The determination of flight crew training requirements was approached from a management point of view.

Webb, N.M. Learning in individual and small group settings. Personnel and Training Research Programs Psychological Sciences Division, Office of Naval Research, TR-7, Arlington, VA, 1977.
Learning in individual and small group settings were compared. Differences were presented as a function of both student ability and group process. Individual achievement, ability level, and aspects of group interaction were investigated.

Williges, R.C., Johnston, W.A., & Briggs, G.E. Role of verbal communication in teamwork. *Journal of Applied Psychology, 1966, 50*(6), 473-478.
Verbal communication between teammates was examined as to when it was necessary and when it was unnessary for task performance. The task used was a simulated radar-controlled aerial intercept. Training transfer from one condition to another was also investigated.

Wood, M.E. *Improved crew member training through a new philosophy toward training.* AFHRL-TR-70-31, AD-723 313. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, August 1970.
An effective technique for implementing a process-oriented instructional system was defined and described. The systems approach to training was emphasized and the use of behavioral objectives defined in observable terms was stressed.

Yaeger, B.W., & Bell, J.D. Techniques of quantitative performance measurement for ASW team trainers. Honeywell Marine Systems Division, California Center. *10th NTEC/Industry Conference,* 1977.
This paper was aimed at the improvement of evaluation techniques for complex interrelated performances in team exercises. Means for providing detailed measures of team, subteam, and individual performances were detailed. A model was provided.